Machine Monitoring - A Market Study with Application of Business Model Innovation Theory

A thesis submitted in partial fulfilment

of the requirements for the Degree of

Master of Engineering

by Rajan Fernandez

University of Canterbury

2013

PREFACE

The work presented in this thesis documents an investigation that was performed for Sulzer Ltd., a currently operating company. Primary documentation of this investigation exists as an internal investigation report at Sulzer Ltd. This thesis was subsequently created to partially fulfil the University of Canterbury requirements for the degree of Master of Engineering, and is essentially a copy of the aforementioned investigation report with some of the content removed.

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Condition monitoring business has been of interest to Sulzer since the 1990s when the Sulzer Diagnostic System (SUDIS) was developed. However, since the invention of SUDIS, Sulzer has had limited commercial success with condition monitoring products and services. Several recent investigations at Sulzer have explored possibilities for new machine monitoring business, with the most recent being the condition monitoring equipment survey of Nyitray. This report leads on from the work of Nyitray to evaluate the attractiveness of current machine monitoring markets and the strength of current and concept control and monitoring business models.

Sales and customer support services (CSS) staff in all business segments and areas were surveyed for information regarding customer demand for machine monitoring solutions. The results of the survey lacked a unified view on customer needs, indicating that customer needs vary significantly with industry and region. Results also indicated that Sulzer sales and CSS staff currently have very little contact with customers regarding machine monitoring issues, which was expected since Sulzer currently has very limited machine monitoring offers. Overall customer interest in machine monitoring for cost saving purposes is high. Moreover, some customers expect equipment manufactures like Sulzer to support their equipment with machine monitoring offers.

Business model environmental factors for each Sulzer Pumps focus market were identified allowing the most attractive markets for machine monitoring business to be selected. A survey of Sulzer Pumps business segment heads also contributed to the market selection process. This evaluation concluded that the water and power generation industries had favourable markets for machine monitoring business, mainly because Sulzer has a good competitive position in these markets. Unfortunately pumps in the electricity generation industry are relatively reliable compared to other machinery such as electrical generators. Hence, opportunities identified in the electricity generation industry seemed to be more appropriate for Sulzer Turbo Services than Sulzer Pumps. However, cross-divisional collaboration of Sulzer Pumps and Sulzer Turbo services would allow Sulzer to offer solutions for entire drivetrains. Other opportunities suitable for Sulzer Pumps were identified in the district heating and water industries, with energy monitoring being a common theme.

An evaluation of the oil pipeline industry yielded that there is significant market demand for machine and pipeline monitoring. However, Sulzer currently does not have the experience or resources to provide the demanded monitoring services independently. Hence searching for key partners or acquisition targets was acknowledged as an essential activity for Sulzer Pumps to enter this market. Another means of market entry would be to develop novel technology or integrate emerging technologies (e.g. online viscosity

sensors) into new pipeline monitoring solutions, i.e. to create a novel value proposition. Subsequent feedback from Sulzer alliance managers concluded that oil pipeline customer acquisition may be difficult since many pipeline companies already have monitoring solutions which they are satisfied with. Hence the oil pipeline market is not recommended for new machine monitoring business ventures.

ABS pump control and monitoring solutions are currently the only machine monitoring solutions offered by Sulzer Pumps. In this study the business model behind these solutions was analysed to evaluate its strength and identify areas for improvement. Although the ABS control and monitoring business model is profitable, sales figures are below their potential. Recommendations to improve the business models effectiveness mainly focused on improving channels through which Sulzer connects with its customers. These included improving Sulzer digital marketing material, improving product selection tools, increasing complementary advertising and quotation contents to connect Sulzer control and monitoring products with pump equipment products, and most importantly increasing the amount of sales and CSS staff training.

ACKNOWLEDGMENTS

The research presented in this thesis was possible thanks to many people. Here I would like to thank everyone that has contributed to the work presented in this thesis, and to my education at the University of Canterbury.

Firstly, I would like to thank Sulzer Ltd. for hosting and sponsoring this project. In particular, I would like to thank Dr. Frank May, Andre Brogli, and Tobias Pforr, for initiating the project and for supervising my work throughout the project duration. I would also like to acknowledge Dr. Ernst Lutz for his support of the project at Sulzer. Secondly, I would like to acknowledge all of the Sulzer employees that contributed to this work. In particular, I would like to thank Jörgen Jäger for his enthusiastic support, commitment, and extensive contributions. Thirdly, I would like to thank Associate Professor Dr. Keith Alexander for supervising the academic component of this project.

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List of Abbreviations

AME	Americas (business area; North, Central, and South America)
ASNT	American Society for Non-destructive Testing
ASP	Asia Pacific (business area)
ASTM	American Society for Testing and Materials
ATEX	Equipment and protective systems for potentially explosive atmosphere (Abbreviation from the French directive title: Appareils destinés à être utilisés en ATmosphères Explosives)
BA	Business Area
BS	Business Segment
C&M	Control and Monitoring
CHP	Combined Heat and Power
CM	Condition Monitoring
CPI	Chemical Processing Industry
CSP	Concentrated Solar Power
CSS	Customer Support Services
DCS	Distributed Control System
DIN	Deutsches Institut für Normung
DOE	Department of Energy
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
EMEA	Europe, the Middle East, and Africa (business area)
EPC	Engineering, Procurement and Construction
ERD	Equipment Reference Database
EV	Enterprise Valuation
FERC	Federal Energy Regulatory Commission
GI	General Industry
GKM	Grosskraftwerk Mannheim
HPI	Hydrocarbon Processing Industry
HRPT	Hydraulic Power Recovery Turbine
IEM	Industrial Equipment Manufacturer
IntO	Intelligent Observer
ISO	International Organisation for Standardisation
LCC	Life Cycle Costs
NE	New Equipment
O&M	Operations and Maintenance

OEE	Overall Equipment Efficiency
OEM	Original Equipment Manufacturer
OG	Oil and Gas
PG	Power Generation
PHMSA	Pipeline and Hazardous Materials Safety Administration
PLC	Programmable Logic Controller
PPI	Pulp and Paper Industry
PPS	Pro Pump Services
PV	Photovoltaic
RFP	Request for Proposal
ROA	Return on Asset
ROAR	Return on Asset Reliability
ROI	Return on Investment
SCADA	Supervisory Control and Data Acquisition
SOI	Savings on Investment
SP	Sulzer Pumps
SPP	Sulzer Process Pumps
SSO	Sanitary Sewer Overflows
STLE	Society of Tribology and Lubrication Engineers
SUDIS	Sulzer Diagnostic System
SWOT	Strength, Weakness, Opportunity and Threat
UCP	Unit Control Panel
VSD	Variable Speed Drive
W	Water
WW	Waste Water
WWS	Waste Water Solutions

Chapter 1

Introduction

1.1 Background

Since the creation of the Sulzer Monitoring and Diagnostics System (SUDIS) in the early 90s Sulzer has been trying to obtain a position in the condition monitoring market with limited success. Early products such as SUDIS and SmartMonitor (see Section 3.6) were highly sophisticated monitoring systems that failed in the market due to their complexity and high cost. Later, Sulzer adopted a new approach aiming to offer customers a package comprising minimum hardware and expert diagnostic services (Sulzer Ltd, 2006a). This led to the development of the Intelligent Observer (IntO) (Section 3.6), a condition monitoring device, and Power Calc software. However, the success of these products in the marketplace fell short of expectations.

Over recent decades the condition monitoring equipment and service markets have displayed tremendous potential due to increasing awareness levels of the benefits of condition monitoring systems (Vidyasankar, 2005). During 2007 and 2008, technology innovation, growth opportunities and market acceptance were high and the condition monitoring market was considered to be its peak (Frost & Sullivan, 2011). The following period of economic uncertainty in 2008-2009 saw most industries reduced their spending on condition monitoring equipment to focus investments on short-term gains causing the market to decline. Larger users of condition monitoring systems such as oil and gas and power generation maintained a reasonable level of demand during this period while a surge of demand from other industries was delayed until 2010. This made 2010 the turnaround year for condition monitoring as smaller user segments such as mining and waste water drove demand back up (Frost & Sullivan, 2011).

In 2011 Sulzer Pumps committed to investment in the water megatrend by acquiring of Cardo Flow solutions. Not only did this investment in waste water technology complement Sulzer Pump's existing water production and transport business segment, it also meant the addition of ABS control and monitoring solutions to the Sulzer product line. The Goldman Sachs water technology continuum (Goldman Sachs, 2008) shows that these higher technology products open Sulzer's product portfolio to high growth markets (i.e. control and automation markets).

At present, ABS control and monitoring solutions hold a small market share in the water control and monitoring equipment market. Although these products are selling more successfully than previous monitoring solutions offered by Sulzer, sales still fall short of expectations. Currently Sulzer is still actively looking to improve its position in the machine monitoring market and would like to develop new business models around service-based business opportunities.

1.2 Recent Condition Monitoring Case Studies and Suggested Business Cases at Sulzer

1.2.1 Customer Response to Life Cycle Cost Modelling

In 2007 and 2008, Sulzer customer support services (CSS) investigated how life cycle costs were modelled in the oil and gas and power industries (Thomson, 2008). Customer interviews determined that pipeline and alliance customers had their own LCC models and were not interested in sharing models or model data. Saudi Aramco was one of a few clients interested in LCC, but only for energy concerns.

The same study also revealed that engineering, procurement and construction (EPC) services were becoming more popular, which had lead interest in LCC analysis to decline. This is because EPC companies were only responsible for a project during installation and warranty periods which last approximately 24 months. Hence they were not interested in long term project factors such as LCC optimisation. Similarly, customer support services in Germany found that approaching high-level managers with LCC models did not lead to successful sales. Instead approaching plant engineers with LCC models proved much more successful (Thomson, 2008).

1.2.2 Electronics for Pumps: The Possibilities to Develop 'Smarter' Process Pumps

Process pumps consume a significant portion of the world electrical energy supply and are often not run at their peak efficiency. One method of increasing pumping system efficiency is by controlling the speed of the impeller in order to reduce the amount of waste energy at throttling valves. For pumps driven by an electric motor this can often be done with a variable speed drive (VSD). This study concluded that automation technologies such as variable speed or variable frequency motor drives may be used to optimise a pump and its system. A brief competitor analysis for pump controls was also documented. Recommended future work included a detailed competitor and market analysis to determine the attractiveness of such technologies to customers (Kisoryo, 2010).

1.2.3 International Technology and Market Analysis for Condition Monitoring Systems of Industrial Pumps in Selected Market Segments

A mechanical seal is a key pump component that is prone to premature failure. Sulzer has developed a concept business case for offering the condition monitoring of mechanical seals (Kisoryo, 2011). However, since technology for predicting mechanical seal failure is relative young, investment in this area is relatively high risk.

1.2.4 Energy Efficiency Potential in Oil Pipelines

Large pumps used in pipeline operations have achieved efficiencies of approximately 90 % on the test bed. However, when these pumps are under real conditions they are typically running under peak efficiency. In pipeline operations, energy usually accounts for 60 % - 80 % of the total operating cost. Hence energy efficiency is very significant for pump operator in this industry. It has been proposed that Sulzer provide a condition monitoring service to pump operators that includes auxiliary services such as efficiency monitoring and consulting (Sulzer, 2012).

1.2.5 Condition Monitoring Technology

Most recently, Sulzer has reviewed its own condition monitoring technology and those of its competitors (Nyitray, 2013). This report contained a comprehensive guide to condition monitoring equipment that is currently on the market.

1.3 Objectives of the Current Study

The aim of this study was to provide a market analysis to complement the recent study on condition monitoring technology (Nyitray, 2013) (Figure 1.1). The combination of these studies should provide insight into the current market requirements for condition monitoring products and services.

- The primary objective of the current study was to identify the present and future market requirements for condition monitoring products and services.
- The secondary objective was to develop a business model that would satisfy these requirements.

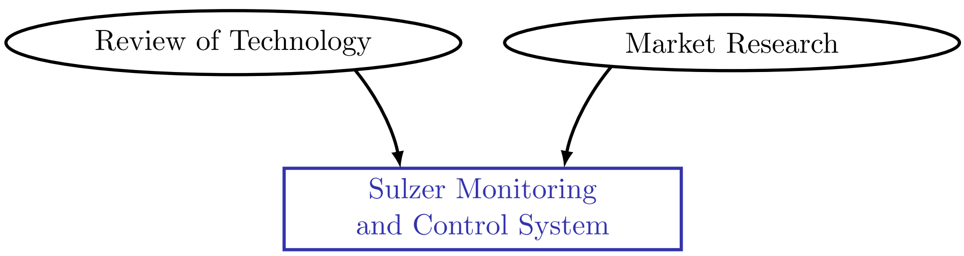

Figure 1.1. Summary of recent Sulzer case studies in the area of condition monitoring

1.4 Scope of the Current Study

The scope of this project was:

1. Introduction to Sulzer Pumps, its markets and products and to condition monitoring in general
2. Identification and evaluation of the key players in Sulzer Pumps in order to gain information about outages, spare pares, failures, etc.
3. Interviews of the identified key players.
4. Analysis of the interviews and information obtained.
5. Definition of market requirements in condition monitoring.
6. Development of business cases for Sulzer Pumps in condition monitoring.

1.5 Research Plan

The current study was divided into two stages to address the two main objectives set out in Section 1.3. These two stages are shown in Figure 1.2 and Figure 1.3 which outlines the structure of the current study. Due to time limitations of the project it was deemed impractical to analyse the requirements of all Sulzer Pump's focus markets. Hence stage 1 of the study involved identifying the most attractive market segments for Sulzer Pump's to enter with machine monitoring solutions. This task involved conducting a literature review along side a review of previous internal research. Next the chosen market subsegments were further analysed to identify specific market requirements in the form of value propositions paired with customer segments.

In the second stage of the project, the paired value propositions and customer segments identified in stage 1 were used as the base components to develop concept business models using the business model canvas (see Section 4.2). These concept business models were then evaluated to identify their strengths and weaknesses, and suggestions to improve them were made. Note that business model improvement were not tested or validated due to the limited project duration.

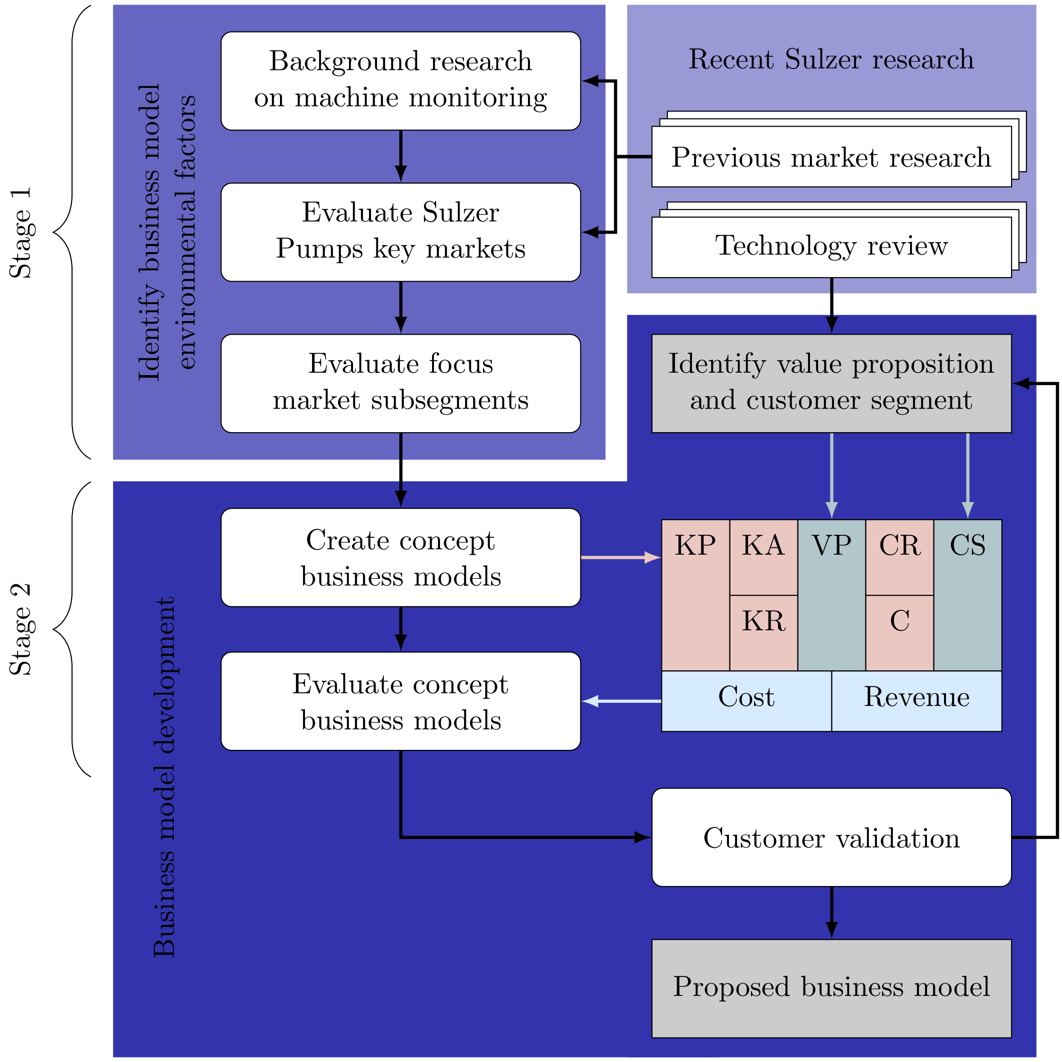

Figure 1.2. Research plan for the current study

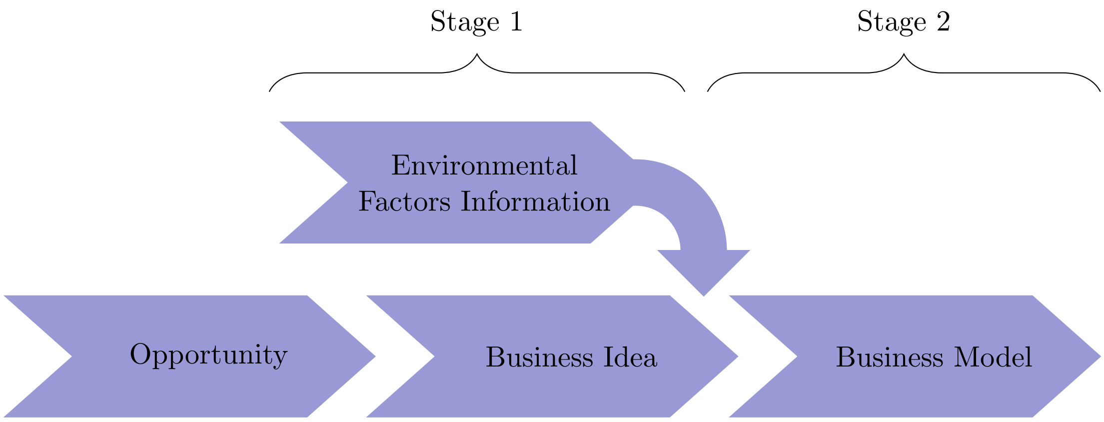

Figure 1.3. Opportunity development process (Baas, 2008)

1.6 Research Methodology

For the current study, several sources of information were utilised to gain qualitative and quantitative data on the market demand for condition monitoring and energy monitoring. Moreover, different methods of data collection were used to target different sources of information as the project progressed. In this section, a summary of the data collection methods used in this study are mentioned.

1.6.1 Background Research

The majority background information was found through reviewing various written resources. Such resources included news articles, competitor marketing material, technical reports, academic journal articles, market analysis reports, industry magazine article, industry regulations and industry guidelines. Internal resources at Sulzer, such as previous investigation reports, financial reports, company reports, investor relations documents and staff training modules were also used. Background information was also gathered through correspondence with Sulzer staff.

1.6.2 Market Research

Literature sources as described in the previous section were also used for market research. However, to gain a view of the present market conditions correspondence with

Sulzer staff who regularly interact with Sulzer's customers was essential. Personal communication with staff was done via phone calls and email, while larger staff groups were accessed via online based surveys.

1.7 Internal Research Resources

Besides publicly available publications, several internal resources at Sulzer were used to evaluate Sulzer Pumps current markets. These resources are described in the following subsections.

1.7.1 Sulzer Intranet

Sulzer's local intranet (named SulzerNet) provides Sulzer employees access information about Sulzer's organisation structure, financial reports, company regulations and policies, internal news, and other Sulzer publications. SulzerNet is often a good place to start when searching for contacts within the company or information on department roles.

1.7.2 Sulzer Speed

Sulzer Speed (http://speed.sulzer.com/) is Sulzer Pumps global intranet site. This key resource contains a multitude of information on Sulzer Pump's product line, organisation structure, management structure, and key contacts. It also contains a collection of Sulzer Pumps market support documentation, employee training material, database accesses links, and internal communications and news updates. Sulzer Speed is one of the most useful resources at Sulzer Pumps for finding internal information and documentation. New users of Sulzer Speed should refer to the quick start guide available on the Sulzer Speed homepage.

1.7.3 Equipment Reference Database

Sulzer Pumps equipment reference database (ERD) is a central record of all installed Sulzer Pumps. The ERD web interface is accessible through Sulzer Speed and allows the user to search the database entry attributes. This tool was employed throughout the present study to estimate the install base population for particular Sulzer pumps. Note that pump populations extracted from this database should be treated as estimates only as customers have no obligation to inform Sulzer when a Sulzer pump is taken out of service. Moreover, the database was known to have repeat entries and was presently undergoing a 'data cleansing' process.

1.7.4 Spare Parts Application

Similar to the equipment reference database (see Section 1.7.3), Sulzer Pumps spare parts application (SPA) allows users to view information on installed Sulzer Pumps and also spare parts. However, the entries in the SPA database have significantly more attributes assigned to them. Using the SPA tool the users can check if a specific pump is in service by checking the value of an entry 'IsActive' attribute. However, similar to entries in the ERD, there is significant uncertainty associated in this attribute since it relies on customers informing Sulzer when they decommission a pump.

1.8 Project Timeline

The current study was originally planed as a 6 month internship at Sulzer Pumps. However, the project was subsequently extended by 2 months due to further work being available. Work on this study commenced in mid January 2013.

1.9 Referencing in this Report

Much of the information in this report has been obtained through word of mouth or correspondence by other means with Sulzer employees. Most of this information is undocumented and only accessible through the experience of these key personal. Instead of referencing correspondence, sources are mentioned by name throughout this report. The name and present job title of referenced persons can be found in Appendix A.

Cited documents or otherwise tangible sources of information are referenced numerically in superscript throughout the main text. Details of these references can be found in the references section following the report conclusion chapter.

1.10 Chapter Preview

This report begins by providing an overview of Sulzer Company, highlighting the present structure of Sulzer's Pump division in Chapter 2. Next the activities of condition monitoring and energy monitoring are introduced in Chapter 3, with an overview of Sulzer Pump's experience in these fields. Chapter 4 introduces the concept of business model innovation and how it can be applied at Sulzer. Some of Sulzer Pump's past business models are also analysed.

Chapter 5 presents the design and results of a survey that was distributed to Sulzer CSS and sales staff to evaluate the current customer demand for machine monitoring solutions. In Chapter 6, Sulzer Pumps focus markets are evaluated to determine the most attractive market to approach with a new monitoring service business. This evaluation was necessary to narrow the scope of the current study. The chosen focus markets are analysed further in Chapter 7 to identify specific value propositions with paired customer segments.

In Chapter 8, machine monitoring opportunities in the pipeline industry are investigated and a business model based on a recent request for proposal is presented. Chapter 9 presents an analysis of the current Sulzer ABS control and monitoring solutions business model and suggestions for improvements. Finally, conclusions of the current study are set out in Chapter 10 with recommendations for further work.

Chapter 2

Sulzer Company

2.1 About Sulzer Company

Sulzer is a diverse company that offers technology and expertise to a broad range of industries. Established in 1834 in Winterthur, Switzerland, Sulzer's extensive history with pump technology has lead to the company to become a leading player in the pump market. Sulzer takes pride in offering innovative solutions to its customers, and recognises that continuous research and development play a vital role in the company's sustained success.

2.2 Divisions of Sulzer

Sulzer Company is made up of five major divisions: Sulzer Pumps, Sulzer Metco, Sulzer Chemtech, Sulzer Turbo Services, and Sulzer Innotec. The current study was done primarily in the interests of Sulzer Pumps. However, the outcomes may also be relevant to the business of Sulzer Turbo Services.

2.3 Sulzer's Key Markets

Sulzer offers a diverse range of products and services which leads to Sulzer having a presence in many industries. Some of these industries are:

- Automotive
- Aviation
- Chemical processing
- Health care
- Hydrocarbon processing
- Oil and gas
- Power generation
- Pulp and paper
- Water

Sulzer also has business within other industries, but these are what Sulzer considers its key markets. Of these industries, focus markets specific to Sulzer Pumps lie in the industries of oil and gas, hydrocarbon processing, power generation, water, and pulp and paper (Sulzer Ltd, 2013h). All other markets for Sulzer Pumps are classified as general industry.

2.4 Sulzer Pumps Business Areas and Segments

Sulzer Pumps operations are organised into geographical business areas (BAs) and industry segments. In total there are five business areas. Three of these areas have geographical restrictions (Figure 2.1) and two are global. The three restricted business areas form a group named Engineered Solutions, while the two global business areas fall into the group Configured Solutions. Sulzer also categorises industry into six segments, but not all business areas are active in each segment. Table 2.1 is an overview of the present structure of Sulzer Pumps showing which market segments each business area is active in. However, note that the company structure is subject to change. Sulzer Pumps plans to restructure and consolidate its organisation in the near future.

Table 2.1. Sulzer Pumps business areas and segments matrix with the current segment heads and CSS business area heads listed

<table>
<tr><td colspan="2" rowspan="5"></td><td colspan="6">Business Areas</td></tr>
<tr><td colspan="4">Engineered Solutions</td><td colspan="2">Configured Solutions</td></tr>
<tr><td rowspan="2">Europe, Middle-East & Africa</td><td rowspan="2">Asia Pacific</td><td colspan="2">The Americas</td><td rowspan="2">Sulzer Process Pumps</td><td rowspan="2">Waste Water Solutions</td></tr>
<tr><td>NAM</td><td>SAMSA</td></tr>
<tr><td>EMEA</td><td>ASP</td><td colspan="2">AME</td><td>SPP</td><td>WWS</td></tr>
<tr><td rowspan="7">Market Segments</td><td>Oil and gas</td><td colspan="4">Rich Niiranen
(Portland, USA)</td><td></td><td></td></tr>
<tr><td>Hydrocarbon Processing</td><td colspan="4">Mick Wigglesworth
(Leeds, UK)</td><td></td><td></td></tr>
<tr><td>Power Generation</td><td colspan="4">Joachim Schulz
(Winterthur, Switzerland)</td><td></td><td></td></tr>
<tr><td>Water</td><td colspan="6">Marcos Koyama (water production and transport) and Giorgio Sabbatini (waste water)
(Winterthur, Switzerland)</td></tr>
<tr><td>Pulp and Paper / General Industry</td><td></td><td></td><td colspan="2"></td><td colspan="2">Teijo Rajamaki
(Karhula, Finland)</td></tr>
<tr><td rowspan="2">Customer Support Services</td><td colspan="6">Andre Brogli
(Winterthur, Switzerland)</td></tr>
<tr><td>Andrew Percy
(Leeds, UK)</td><td>Shawn Bai
(Shanghai, China)</td><td colspan="2">Roy Horner
(Pennsylvania, USA)</td><td colspan="2">Veli-Pekka Tiittanen
(Winterthur, Switzerland)</td></tr>
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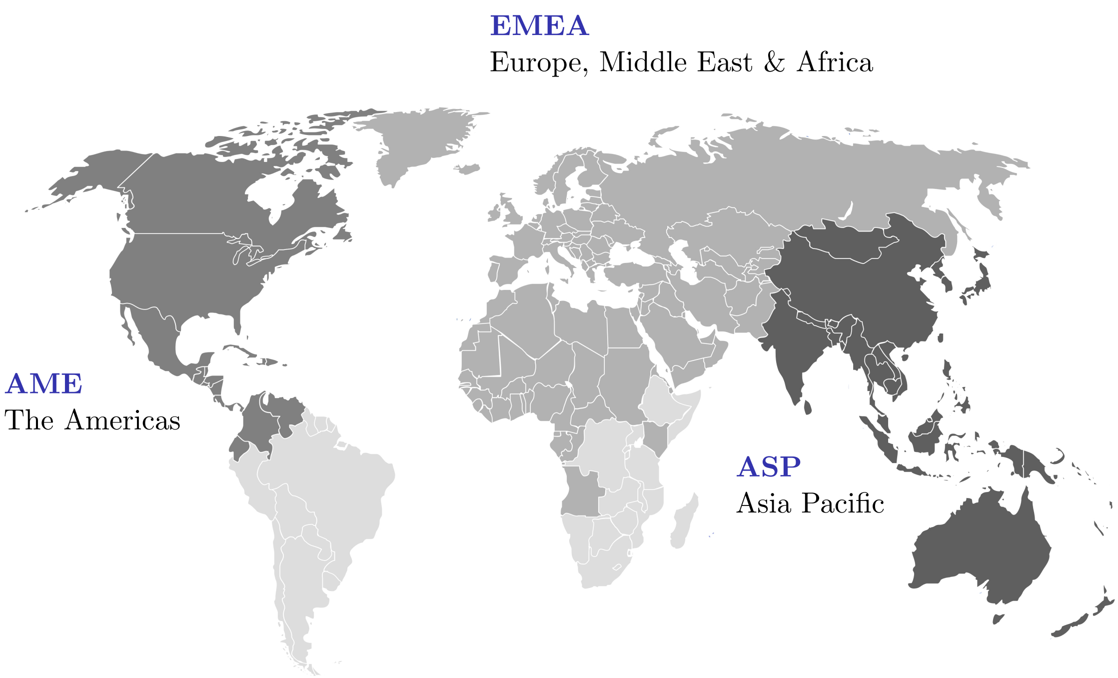


Figure 2.1. Sulzer business areas and global locations (*Image source: www.sulzer.com*)

2.5 Sulzer Pumps Global Presence

As shown in Figure 2.2, Sulzer Pumps has representatives in over 140 countries around the globe. This includes over 60 services facilities to ensure excellent responsiveness of Sulzer customer services. Figure 2.2 highlights the locations of Sulzer customer support services (CSS) in blue. Staff at these locations are an invaluable source of information for the current study.

2.6 Sulzer Department Roles

2.6.1 Business Intelligence

Business intelligence is tasked with analysing and evaluating the business environment surrounding Sulzer. They do this by maintaining a systematic database containing information on the market, competitors, customers, and suppliers. Business intelligence is also responsible for providing advice for strategic business decisions.

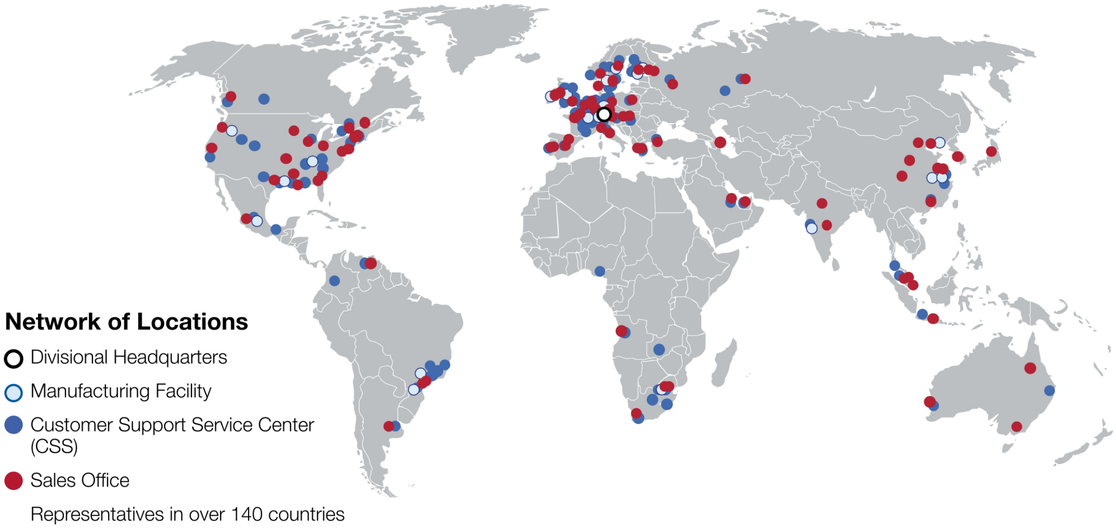


Figure 2.2. Sulzer Pumps locations (Sulzer Ltd, 2013e)

2.6.2 Business Development

Business development is a level of management concerned with making strategic decisions that will affect the long-term value of Sulzer. They combine information from business intelligence, customers, industry news, and other sources into concise market analyses which justify plans for future company objectives and activities. They are also responsible for providing advice on acquisitions from their market analyses.

2.6.3 Customer Support Services

Customer Support Services (CSS) provide a range of technical services to Sulzer customers. Some example CSS services are on-site inspection and troubleshooting of equipment, machinery maintenance management, equipment retrofitting and upgrades, and asset management. Since CSS staff work closely with customers on a regular basis, they were a valuable internal source of information on the present customer needs.

2.6.4 Sales

Sulzer sales force is responsible for managing equipment sales from quoting to delivery. They are primarily concerned with new equipment sales as spare parts and servicing are handled by customer support services (Section 2.6.3).

2.6.5 Product Development

Product development staff work towards improving technical aspects of Sulzer products. This involves improvements to the current product line and the development of new products.

2.6.6 Corporate Communications

The communications team supports maintaining professional means of internal and external relations. In the current study, the communications team provided an access to an organised platform for internal surveys.

Chapter 3

Machine Monitoring

3.1 Costs of Running a Machine

The life cycle cost (LCC) is the total cost of an asset over its life time from acquisition to disposal (Hydraulic Institute, Europump, & U.S. Department of Energy Office of Industrial Technologies (OIT), 2001). Equation 3.1 shows how the life cycle cost of a machine is the sum of eight types of costs. Of these costs maintenance and running costs (C_e, C_o, C_m and C_s) are typically the most significant contributors towards the total life cycle cost of a machine. The initial cost of the machine (C_{ic} and C_{in}) is usually minor in comparison. Hence there is a strong demand for machine management equipment and services to optimise return on assets.

$$LCC = C_{ic} + C_{in} + C_e + C_o + C_m + C_s + C_{env} + C_d \tag{3.1}$$

where:

C_{ic}	-	Initial cost or purchase price
C_{in}	-	Installation and commissioning costs
C_e	-	Energy costs
C_o	-	Operating costs
C_m	-	Maintenance costs
C_s	-	Downtime, cost of loss of production
C_{env}	-	Environmental costs
C_d	-	Decommissioning and disposal costs

Once a machine is in service it can either be running (uptime), idling, or undergoing maintenance (downtime). Of these three states idling is the worst since the machine is capable of running but not producing any output. Hence idling is avoided at all costs through careful scheduling of operations. Assuming that operation schedules are optimised to the point of zero idle time, the only states left to consider are the uptime and downtime of the machine. This is often done through machine monitoring. There are two major types of machine monitoring. Firstly, there is condition monitoring (see Section 3.2) which is aimed at minimising downtime of equipment. Secondly, there is energy monitoring (see Section 3.7) which is aimed at minimising the uptime operational costs.

3.2 Condition Monitoring

The bathtub curve shown in Figure 3.1 is often referred to in reliability engineering to describe the likely failure of a product. It shows how the overall failure rate of a product comprises the number of products that fail early and the number of products that wear out. This curve often well represents the failure rate of mass produced consumer products. However, in the case of industrial machinery produced in low volumes failures are predominantly due to components wearing out.

Wear of machine components can often cause machinery to fail without warning. This can be inconvenient and costly for machine operators, especially when maintenance of the machinery was not planned. Although it is impossible to prevent some machinery components from wearing out, operator can monitor their condition so failures come at

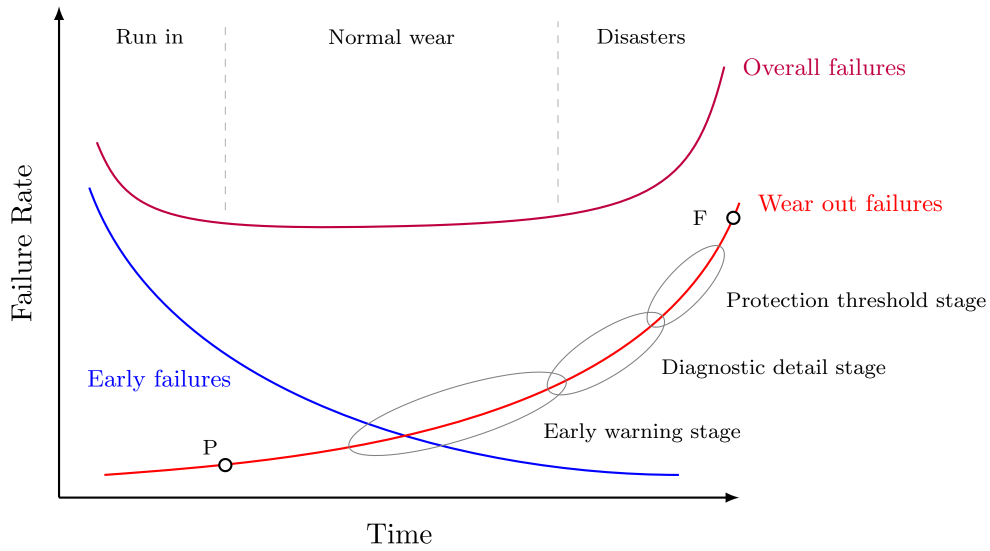


Figure 3.1. The bathtub curve for reliability is the result of early failures and wear out failures. The wear out failure curve shows the points of potential or probable failure (P) and functional failure (F)

less of a surprise. This practice is known as condition monitoring.

Condition monitoring was initially practiced to avoid disastrous failures of machines where reliability was critical, for example, in nuclear power plants or submarines. However, over time, businesses began to adopt condition monitoring strategies as it gave them a competitive advantage in the marketplace (Ivara Corporation, 2009). Since even planned maintenance may involve costly downtime, optimisation of maintenance plans can be crucial. If an operator can predict a failure further in advance they have more time to plan the required maintenance. Figure 3.1 shows three different time periods where a failure may be detected. Firstly is the early warning stage. This is a period where it first becomes possible to detect symptoms of the oncoming failure. Following this comes a period when the failure symptoms become easy to measure and monitor. By now trends in monitoring data may become clearer and point towards a specific fault. Finally comes a period when symptoms are prominent enough to trip any machine protection devices that are in place, forcing the operator to thoroughly investigate and remedy the fault.

3.3 Condition Monitoring Strategies

A broad range of condition monitoring strategies exists, from simply running equipment until failure occurs, to the use of advanced technology for predicting failures. In any case, each strategy can be classified as a preventive and/or predictive maintenance plan. Preventive maintenance describes any maintenance strategies where decision making is based on the past and present operating condition of monitored equipment. Whereas predictive maintenance describes maintenance strategies based on predicting the optimal time and method for servicing equipment.

Figure 3.2 shows that a preventive and predictive maintenance systems use a common process structure, and the only real difference is in the complexity of data analysis and forecasting. Preventive condition monitoring often includes feedback to the pump system in the form of machine protection trips (Figure 3.2). However, predictive maintenance systems generally have no direct feedback since they are not focused on immediate issues, but on forecasting. Figure 3.3 shows which condition monitoring strategies can be classified as preventive or predictive maintenance. Each of these strategies is defined in more detail by Nyitray (2013). Whether preventive or predictive maintenance strategies are used, the objective of condition monitoring remains the same. That is, to maximise asset reliability and performance whilst minimising the assets life cycle cost.

3.3.1 Targeting 'Bad Actors'

The Pareto principle (also known as the 80/20 rule), named after the Italian economist Vilfredo Pareto states that in many events, roughly 80 % of effects originate from roughly 20 % of the causes. In engineering this principle can be used to describe cases where 80 % of maintenance issues come from approximately 20 % of the machine population. Machines in this minority population usually hold a reputation for repeat failures and are often called 'bad actors'. A common maintenance strategy is to focus on finding long term solutions for bad actors, since they cause the majority of problems. Hence bad actors often warrant investment in condition monitoring solutions to keep total maintenance costs to a minimum.

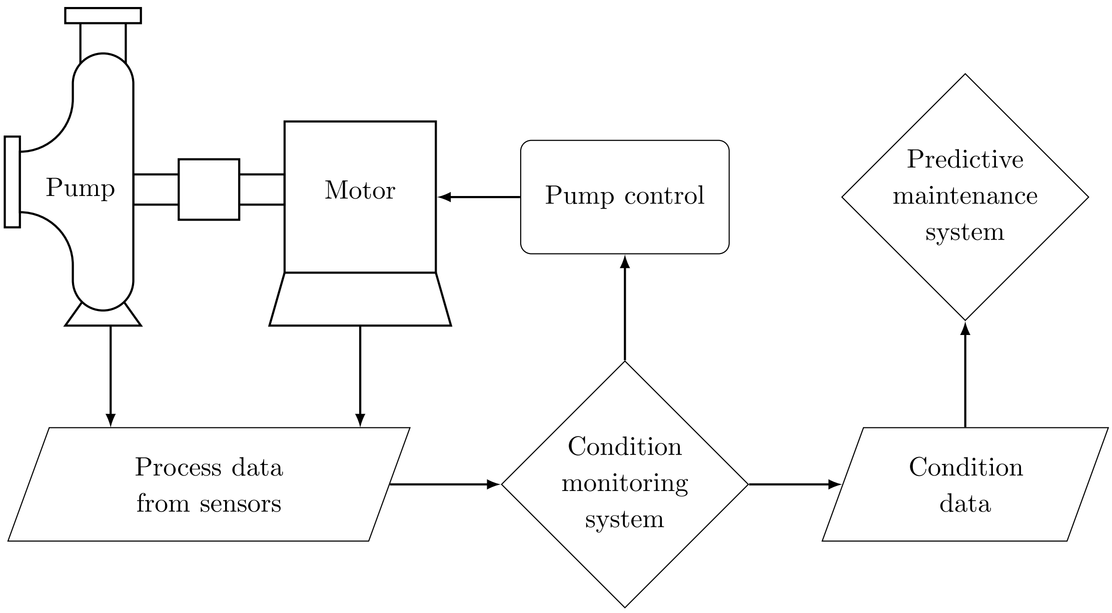


Figure 3.2. Condition monitoring and predictive maintenance system schematic

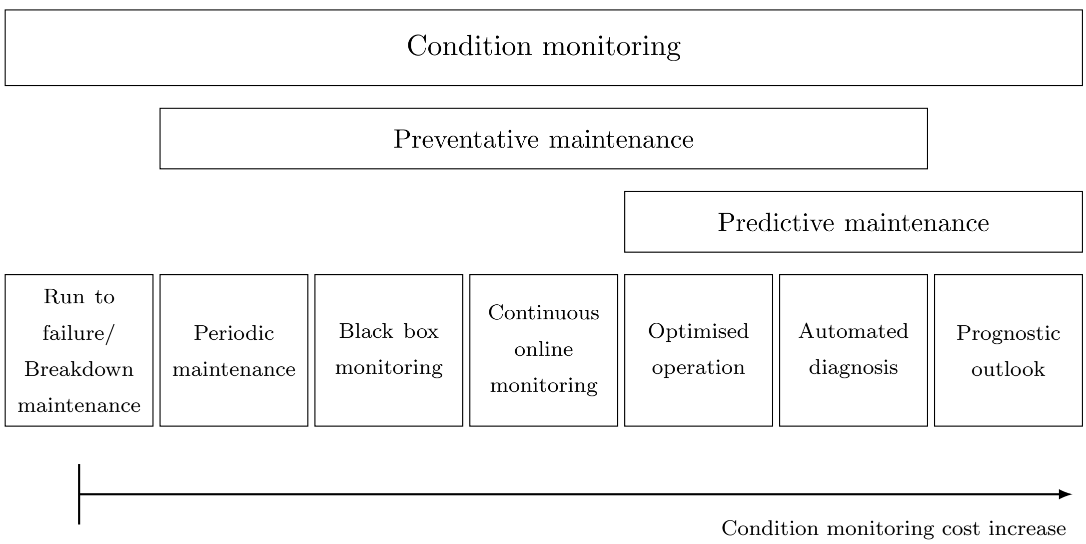


Figure 3.3. Condition monitoring strategies

Table 3.1. Costs and benefits of condition monitoring for machine operators

Benefits	Costs
• Avoiding downtime and production losses • Avoiding unplanned maintenance • Avoid unnecessary open-up inspections • Reducing repair times through properly planned maintenance schedules • Optimising maintenance plans from knowing what the fault is and how severe it is • Improving safety through planned maintenance procedures • Optimising operational efficiency and lowered energy consumption through analysing monitoring data • Catching degrading process quality levels • Reduced insurance costs due to improved asset reliability	• Hardware installation and maintenance costs • Software purchasing or licensing costs • Monitoring service fees • Maintenance staff must be up-skilled to manage the condition monitoring system • Consultations for decision making with the monitoring data

3.4 Costs and Benefits of Condition Monitoring

3.4.1 Costs and Benefits of Condition Monitoring for Machine Operators

Condition monitoring has many benefits for machine operators. However, these benefits come at a cost. Table 3.1 lists some common costs and benefits of condition monitoring from the perspective of a machine operator.

3.4.2 Benefits of Condition Monitoring for Suppliers and Manufacturers

Not only is condition monitoring beneficial for the operators, but also for condition monitoring suppliers and machine manufacturers provided operators allow them access to their condition monitoring data. Condition monitoring service suppliers may use data collected during monitoring to develop more advance methods for predicting failures. This can lead to improved predictive maintenance services for the end user. Machine manufacturers may also benefit from interpreting condition monitoring data, as it may provide useful insights into improving the design of their equipment. Furthermore, condition monitoring data can aid decision making when it comes to warranty claims.

3.5 Adoption of Condition Monitoring in Industry

There are several factors which have either accelerated or retarded the adoption of condition monitoring systems in industry. This section contains a few examples of such factors.

3.5.1 Developing Technologies

New and more cost effective technology has promoted the condition monitoring market to grow. Currently the developments are focusing on making condition monitoring information readily available. This trend has led to many suppliers adopting web-based systems and developing functional user interface designs, allowing users to clearly view and interpret condition monitoring results. Modern software is being designed for devices with multi-touch screens so that data can be viewed clearly on tablets and smartphone devices.

3.5.2 Industry Safety Standards

In several industries condition monitoring systems are required to operate in hazardous environments where machinery must meet rigours safety standards. Different countries are governed by different regulations and so several standards are available for classifying hazardous areas. In Europe, hazardous area containing explosive substances are often classified as one of the following three zone in accordance with IEC60079-10-1, Explosive atmospheres standard.

Zone 0 An area in which an explosive gas atmosphere is present *continuously*, for long periods of time or frequently

Zone 1 An area in which an explosive gas atmosphere likely to occur in normal operation occasionally

Zone 2 An area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only

Equipment operating within these zones are often required to meet certain health and safety requirements. In Europe, on July 1st 2003, it became mandatory for all instrument and electrical manufacturers and suppliers to certify their products via the ATEX (explosive atmospheres) directive. Hence, safety regulations such as this must be carefully considered when designing condition monitoring equipment.

3.5.3 Reaching the C-Suite

Law (2000) of Bently Nevada Corporation stated that“return on investment (for asset management and condition monitoring) is often measured in the range of ten times the cost and higher”. Even though statements such as this sound very impressive, it is hard to convince high level managers to invest in condition monitoring without a credible estimate for their return on investment (ROI) (see Section 3.13.2). This is reflected in recent reports from Plant Services (2013) and condition monitoring service provider DLI (2010). Hence, providing customers with a detailed financial plan exposing the value of a condition monitoring system is crucial in capturing their attention.

3.5.4 Condition Monitoring Standards

There are several standards for condition monitoring available for purchase. The most relevant standards from ISO, ANSI and API are reviewed by Nyitray9 (2012). Recently Europump (2012) has published a brief free guide to condition monitoring which may encourage awareness of the benefits of condition monitoring.

3.6 Sulzer and Condition Monitoring

In this section, a brief overview of Sulzer's history in condition monitoring is provided for reference. For more details on the products mention in this section refer to the proceeding internal case study on condition monitoring technology by Nyitray (2013).

3.6.1 Sulzer Diagnostics System (SUDIS)

Sulzer's first condition monitoring system was called the Sulzer Monitoring and Diagnostics System (SUDIS) and was created in the early 90s. SUDIS was a sophisticated condition monitoring system that included features for predictive maintenance, operating point monitoring, and fault finding. Although SUDIS was deemed one of the most powerful condition monitoring systems of its time (Meienhofer, Krug, & Weschenfelder, 1999), its success was limited by its high cost and its inability to reliably predict the failure of mechanical seals. The later still remains a challenge today. Applications of SUDIS were limited to a few power plants in Germany.

3.6.2 SmartMonitor

SmartMonitor was Sulzer's second generation condition monitoring system that superseded SUDIS in the year 2000. SmartMonitor was an advanced monitoring system that compared monitoring data with a process model to detect growing faults. Similar to SUDIS, SmartMonitor was initially applied in power generation and was installed at Iron Gate hydro power plant in Romania. Later, SmartMonitor was tested on aircraft engines with the support of SwissAir. However, testing ceased when the airline was grounded in 2001. In 2003, Sulzer planned for SmartMonitor to be primarily marketed towards applications the aviation industry, while the applications in power generation took second preference (Bjønness, 2003). This decision was made based on estimates for time to market and target turnover for the year 2008. Within the aviation industry, owner operators such as Lufthansa and Air France were predicted to adopt SmartMonitor initially with maintenance providers and engine manufacturers following thereafter. However, OEM engine manufacturers developed their own monitoring solutions and became the customers preferred supplier by reputation. See Section 4.8.1 for more interpretation of the Smart-Monitor business model.

3.6.3 Intelligent Observer (IntO)

Intelligent Observer (IntO) was Sulzer's second try at a condition monitoring product for the pump market. This small piece of hardware comprised of a stainless steel body (rated IP67) housing a silicone coated PCB. The IntO sported internal vibration and temperature sensors with connections for external temperature, pressure, rotational velocity and flow meter sensors. In addition to this it has one auxiliary connection for miscellaneous sensors. Data from internal and external sensors was stored on internal memory which could later be accessed only by a USB connection. Although customers that purchased an IntO were satisfied with its performance, features that limited its commercial success were its high cost, limited connectivity (USB only), and its designed installation position on top of pumps that was deemed inappropriate. As with SUDIS, IntO was also incapable of monitoring the condition of mechanical seals.

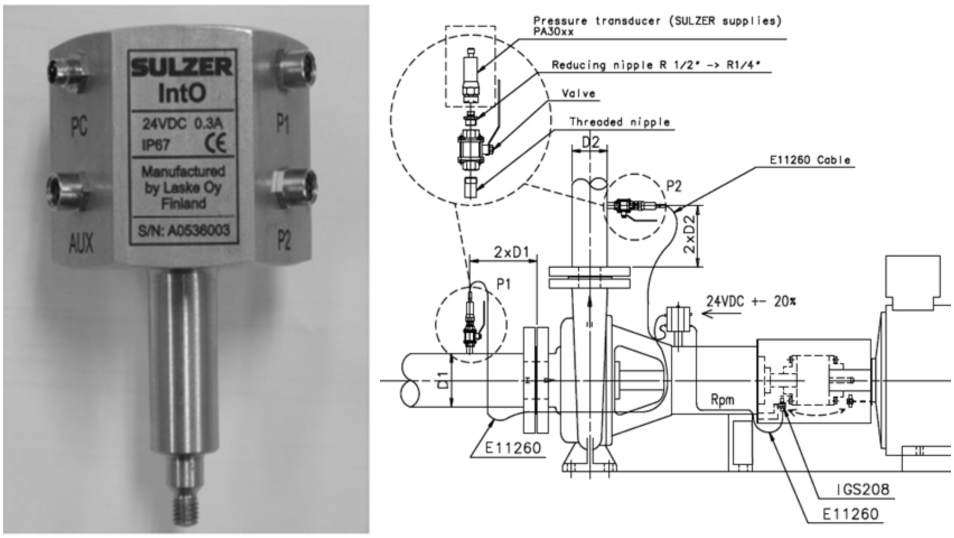


Figure 3.4. Sulzer IntO condition monitoring device with installation drawing

3.6.4 StatorMonitor

StatorMonitor is an online condition monitoring program for electric motors developed by Sulzer Dowding and Mills. This system uses particle discharge measurements to monitor and evaluate the condition of insulation on high voltage motor and generator stator windings (Allen, 2011b).

3.6.5 ABS EffeX Revolution

ABS is a wastewater pumping solutions company that was acquired by Sulzer in 2011. Part of their latest product range includes pump controllers that use monitoring data to increase pump reliability and efficiency. With these first generation pump controllers now on the market, ABS would like to develop a second generation pump controller. Refer to Chapter 8 for details on the ABS EffeX Revolution business model.

3.6.6 IntO 2

Sulzer Pumps Finland was planning to develop a second generation IntO device (see Section 3.6.3 for the first generation). However, during the development phase Sulzer (WWS) acquired Cardo Flow Solutions who were ahead in the development of a similar device at ABS. At this point Sulzer Pumps decided to combine forces with WWS. According to Veli-Pekka Tiittanen, head of CSS for Sulzer configured solutions, this project has been quite for over a year (cited 31$^{\text{st}}$ January 2013).

3.7 Energy Monitoring and Energy Management

As mentioned in Section 3.1, the cost of energy can significantly contribute to the life cycle cost of a machine. This is particularly true if the machine is not operated correctly, or not at it best efficiency point. Hence measuring the energy consumption of a machine relative to its output can provide a good indication of its operating efficiency and condition.

In a report made for the U.S. Department of Energy (Energetics Incorporated & E3M Incorporated, 2004), pump system optimisation was the 6$^{\text{th}}$ best R&D opportunity area for energy saving in mining and manufacturing. Only several heat recovery processes were considered to have higher R&D opportunities. Pump optimisation was also recognised as one of the few opportunity areas that spanned a broad range of industries since pumps are a very common piece of industrial equipment. Furthermore, pump motor drives were identified to consume about 25 % of energy in the manufacturing sector.

Energy savings through pump optimisation in the U.S. were estimated to be in the tens of billions of kilowatt-hours, and hence in the billions of U.S. dollars (Energetics Incorporated & E3M Incorporated, 2004). Similarly, recent reports to Sulzer from Frost & Sullivan (2012) recommended condition monitoring opportunities in the water transport and waste water sectors. Frost and Sullivan also estimated that pumps in water treatment plants use on average 60 % of the energy consumed by the plant. Similarly, the Water Research Foundation (2013) claims that up to up to 80 % of energy for water treatment is consumed by pumps. To generate awareness of the energy used for pumping water, the U.S. Department of Energy (2010) provides a free online tool for calculating pump efficiency. This tool also calculates annual energy consumption and cost from data input by the user.

3.7.1 Energy Consulting

Several services are currently offered by energy consultants, all of which have the end value proposition of saving energy costs of the client. The major difference between different service packages is the frequency at which data is collected and analysed. Current common service packages can be classified as one of four service types depending on their time scale. These categories are: energy planning, energy auditing, energy monitoring and energy management. These four service types are outlined in following sections.

3.7.2 Energy Planning

Energy planning services are offered to clients intending to build new infrastructure for their business. This service entails reviewing client process plans for future operations and making qualified recommendations for the process layout, control and equipment that will minimise energy consumption. This is beneficial to operators as it attempts to low future energy costs.

3.7.3 Energy Auditing

Energy auditing is similar to energy planning. However, this service is aimed at clients with existing infrastructure. Energy auditing is the activity of inspecting the current energy usage of system components to identify where inefficiencies lie. In this case, value is added to a clients business though recommending changes to existing operations that will reduce energy consumption, and hence the operating costs. Like energy planning services, energy audits generally result in a one off report and so are limited to a snapshot of a businesses energy balance. By increasing the frequency of energy audits, businesses can build a history of their energy consumption which can be used to continually improve their operating efficiency.

3.7.4 Energy Monitoring

Although energy audits provide a snapshot of the energy flow throughout a system, some high energy users demand more frequent evaluations of their energy usage. If the frequency of energy auditing is increased to the point where permanent process monitoring systems are in place, the service is now referred to as energy monitoring. The time dependent aspect of energy monitoring means operators are aware of potential energy saving faster, and so potential cost saving through energy monitoring are higher than through energy auditing. Further cost saving can also be made through using energy monitoring data to execute an energy management plan (Figure 3.5).

3.7.5 Energy Management

Energy management can be described as the planning and control of energy usage with respect to location and time (Shi et al., 2012). The objective of energy management is to minimise the energy required per unit output while minimising the total cost of energy used. As shown in Figure 3.5, energy management can not be executed without an energy monitoring system in place. Recently, some companies have started to offer real-time energy monitoring and management packages aimed at minimising the uptime operating costs of high energy users in the clean water industry (Bunn & Reynolds, 2009; Reynolds & Bunn, 2010). Energy management systems (EMS) are often integrated with emis-

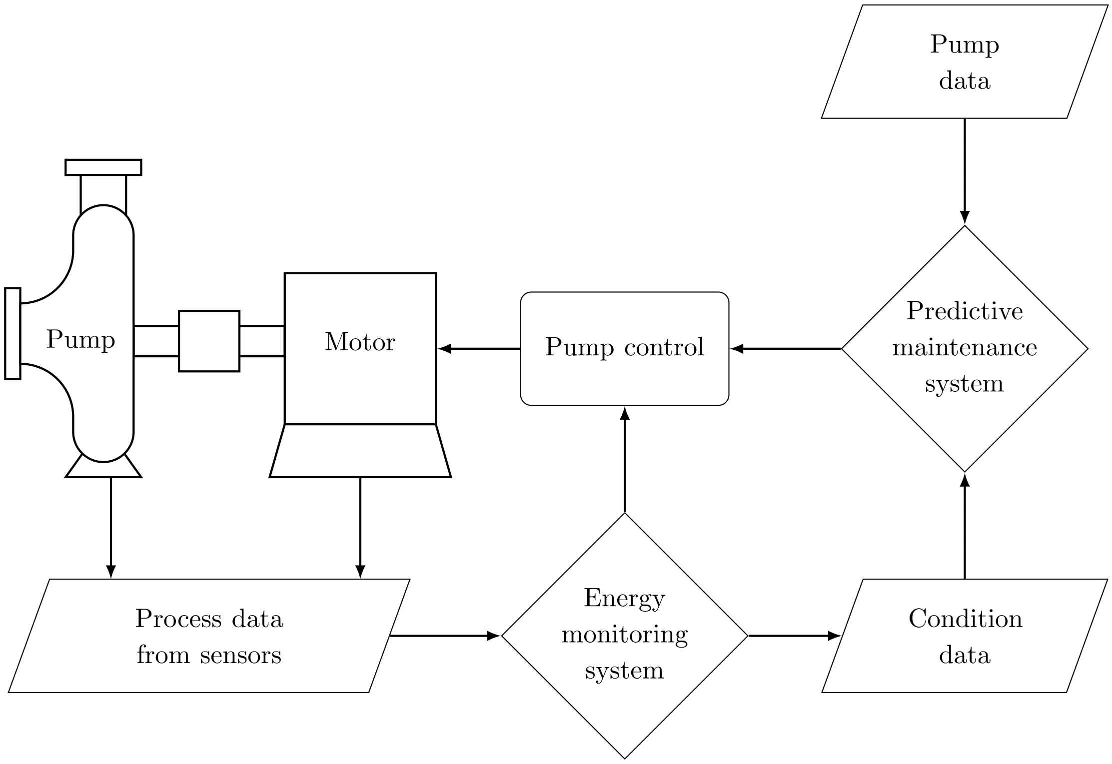


Figure 3.5. Energy monitoring and management system schematic

sions monitoring and condition monitoring systems for convenience and reducing sensor redundancies.

3.8 Costs and Benefits of Energy Monitoring

3.8.1 Costs and Benefits of Energy Monitoring for Machine Operators

The cost of implementing an energy monitoring system is similar to that of a condition monitoring system as most of the required equipment is the same. As shown in Table 3.2, many benefits of energy monitoring contribute towards machine reliability as well. The overlap between these two practices is discussed further in Section 3.12.2.

Table 3.2. Costs and benefits of energy monitoring for machine operators

Benefits	Costs
• Increased pump reliability • Less stress on piping and control valves • Decreased bearing loads • Reduced process noise and vibration in pipes • Fewer leaks caused by vibrations • Increased pump operational efficiency • Reduced energy costs	• Hardware installation and maintenance costs • Software purchasing or licensing costs • Monitoring service fees • Consultations for decision making with the monitoring data

3.8.2 Benefits of Energy Monitoring for Suppliers and Manufacturers

Several competitors are now offering energy auditing services to their customers to raise their awareness of pump efficiency. This service adds value to a customers business through provided expert recommendations on how to reduce their energy costs. By providing this service, competitors will not only benefit from service fees, but will also benefit from insights into how customers operate their machinery. This knowledge may drive product development towards customer needs and aid in improving relationships with customers.

3.9 Adoption of Energy Monitoring in Industry

3.9.1 Energy Efficiency Standards

Recently the British Standards Institution (BSI) has released a standard (BS EN 16247-1 - Energy Audits) to complement the existing international energy management standard (ISO 50001) as a guide for organisations carry out effective energy audits (British Standards Institution, 2012). This standard was developed in response to the 2006 EU directive on energy end-use efficiency and energy services.

3.9.2 Energy Efficiency Legislation, Regulations and Guidelines

As industry and the global population grow, increasing energy usage and CO_2 emissions have become a growing concern. In reaction to this issue several organisations around the world have created guidelines and regulations to promote the efficient operation of high energy usage devices. For example, the European Commission Regulation 547/2012/EC requires water pumps on the European market to meet minimum efficiency requirements. In the U.S., the Department of Energy (DOE) is heavily promoting awareness of energy consumption and provides several free resources to help pump operators better manage their energy usage (U.S. Department of Energy, 2010; U.S. Department of Energy & the Hydraulic Institute, 2006). Similarly in Germany, the German government has implemented Initiative EnergieEffizienz to promote better energy management (DENA German Energy Agency, 2013).

The shift to energy efficient and low-carbon practices in industry is a world trend that is supported by international organisations such as the United Nations. For example, the United Nations Industrial Development Organisation (UNIDO) has several programs aimed at establishing local initiatives to promote cleaner more efficient industry operations (United Nations, 2013b). An example of UNIDO's work is the National Cleaner Production Centre (NCPC) established in South Africa (Department of Trade and Industry, 2013) to host the Industrial Energy Efficiency Improvement Project (IEE Project). Programs such as these aim at reducing national energy demand by increasing awareness of energy efficient practices in industry (Moolman, 2013).

Although these guidelines and regulations promote high energy usage devices to be manufactured and operated efficiently, there are currently no requirements for machine operators to monitoring machine energy efficiency. However, this may change soon in Europe under pressure from the recently released energy efficiency directive (2012/27/EU) from the European Commission. This directive requires EU member states to encourage small and medium size enterprises to undergo energy audits, and large enterprises to undergo mandatory and regular energy audits.

As awareness of energy usage grows governments put in place increasing quantities of legislation limiting the minimum efficiency of high energy usage equipment. Furthermore,

CO_2 emission requirements and taxes are driving businesses to look at their energy consumption more carefully. This was evident in the recent customer survey results of Kisoryo (2011). These market pressures create energy monitoring business opportunities in ensuring that customers meet the required energy consumption standards. Governments are also encouraging firms to invest in energy efficient equipment by offering subsidies to qualifying firms. For example, Germany launched a new energy efficiency program on the 1st of October 2012 allowing companies with less than 500 employees and annual revenues below €100m to apply for grants towards replacing inefficient old equipment (German Trade and Invest, 2012).

3.9.3 Reaching the C-Suite

Similar to condition monitoring cases (see Section 3.5.3) investment in energy audits, monitoring or management often comes down to the decision of C-level executives (U.S. Department of Energy & the Hydraulic Institute, 2006). Hence in addition to evaluating benefits of these services from an engineering point of view, it is vital that they make financial sense for them to sell.

3.10 Sulzer and Energy Monitoring

Sulzer Pumps began a program titled Sulzer Green (GReater Energy Efficiency with New solutions) which focused on enhancing the energy efficiency of pumps. The program focused on making customers aware of potential energy savings through energy auditing services, and was mainly marketed towards customers in the industries of waste water, pulp and paper, and general processing.

Although Sulzer energy audits successfully identified energy saving possibilities for clients (Sulzer Pumps, 2012b), the service was not very popular and was not deemed a commercial success. After conducting energy audits, many customers chose not to continue with the recommended energy saving actions. Even when the return on investment was less than 24 months and when payment plans were offered by Sulzer. Customer reluctance to cost savings through increasing energy efficiencies is still not fully understood. As a result of the low demand for energy audit services Sulzer removed the associated marketing material from their website.

Currently Sulzer Process Pumps (SPP) continues to promote energy auditing with their customers. Although the frequency at which they discuss energy auditing with their customers is increasing they still do not get many orders. Figure 3.6 shows the process for a typical energy audit performed by Sulzer Pumps Finland (Salmi, 2011). After an audit is completed, Sulzer Pumps provides the customer with a report containing their current energy cost, potential energy cost, potential cost savings, a cost estimate for modifications, and the payback time for their investment.

Sulzer has been most active in energy saving and pump control solutions within the water and waste water industries since linking world energy and water demand issues (Sulzer Ltd, 2012c). Product sub-brand ABS is heavily marketing products through the benefits of energy cost savings (Janssen & Albercht, 2011), intelligent controls (Sulzer Ltd, 2013b), and reliability (Barroso, 2011). ABS is also promoting its waste water products and services via convincing case study videos (Sulzer Ltd, 2012a, 2012b).

3.11 Other Energy Saving Efforts of Sulzer

In some systems hydraulic power recovery turbines (HPRT) can be used to recover up to 85 % of hydraulic energy which would otherwise be dissipated at a throttling valve (Adams & Parker, 2011). Sulzer offers customers expertise in modifying and installing reverse running pumps to be used for energy recovery in this way. Recent research at Sulzer Pumps has investigated the potential application of HPRT in municipal water distribution networks (Sulzer Pumps, 2012a).

Recently Sulzer is been involved in energy saving in the oil and gas industry (Heggemann, Vandelli, & Dagha, 2012). By upgrading old pumps with modern components Sulzer was able to significantly reduce the energy used by several water injection pumps. These energy savings also mean reduced CO_2 emissions, which not only saves the environment, but saves the customer carbon tax.

Task	**Result**
Customer contact	The customer is now aware of Sulzer Energy auditing
Agreement on audit	The customer decides to proceed with the audit Audit targets are defined
Review of basic data	Knowledge of plant's key production data is obtained
Definition of scope	A decision is made with the customer on what pumps and/or other equipment should be included in the audit
Review of available data	Preliminary data justifies future data collection
Definition of data sources	An agreement is made with the customer on how data will be collected and who will collect the data
Duration of measurements	The necessary duration of data collection is decided on
Definition of audit schedule	An audit schedule with roles and responsibilities of participants is made
Execution of audit	The audit plan is executed Data is collected and analysed
Data analysis	Reviewing data with the customer makes them fully aware of the main findings
Energy audit report	The energy audit report is delivered to the customer. The report typically includes: • A review of potential savings • Recommended actions • Required investments for these actions • Estimated return on investment
Decision on next steps	

Figure 3.6. Sulzer Process Pumps energy audit process (Salmi, 2011)

3.12 Condition Monitoring versus Energy Monitoring

3.12.1 Requirements for Condition Monitoring and Energy Monitoring

Although condition monitoring and energy monitoring have different objectives, they are actually very similar activities. Both practices require instrumentation, data acquisition devices, data storage, and data analysis. Hence sensors for one system are installed, they other system may be implemented with less effort.

3.12.2 Overlap of Condition Monitoring and Energy Monitoring

Optimising pump reliability (condition monitoring) and energy efficiency (energy monitoring) are not independent goals. As shown by Table 3.1 and Table 3.2 either activity will also benefit the others objective. Moreover, the final objective of either activity is the same; that is minimising life cycle costs. This is illustrated by Figure 3.7 which shows that operating a pump at its best efficiency point will achieve maximum reliability and efficiency simultaneously. Figure 3.7 also shows common forms of damage and reliability issues associated with operation at points either side of the best efficiency point.

This is quite an intuitive conclusion when explained through the principle of energy conservation. When a pump is operated with poor energy efficiency, more energy is being added to the system than is necessary. This excess energy needs to be dissipated somewhere and often causes damage while doing so. Hence, by improving pump efficiency less waste energy needs to be dissipated throughout the pump system, and less wear and damage occurs.

3.12.3 Marketability

Selling a product or service can be very difficult if the value of that product or service is not clear to the customer. As mentioned in Section 3.13, the value of condition monitoring and predictive maintenance programmes can be difficult to quantify due to the unscheduled nature of machine failures. Furthermore, data proving the true value of these programmes requires data covering a substantial portion of the machines life cycle.

In contrast, the time scale required to justify returns on energy monitoring is relatively

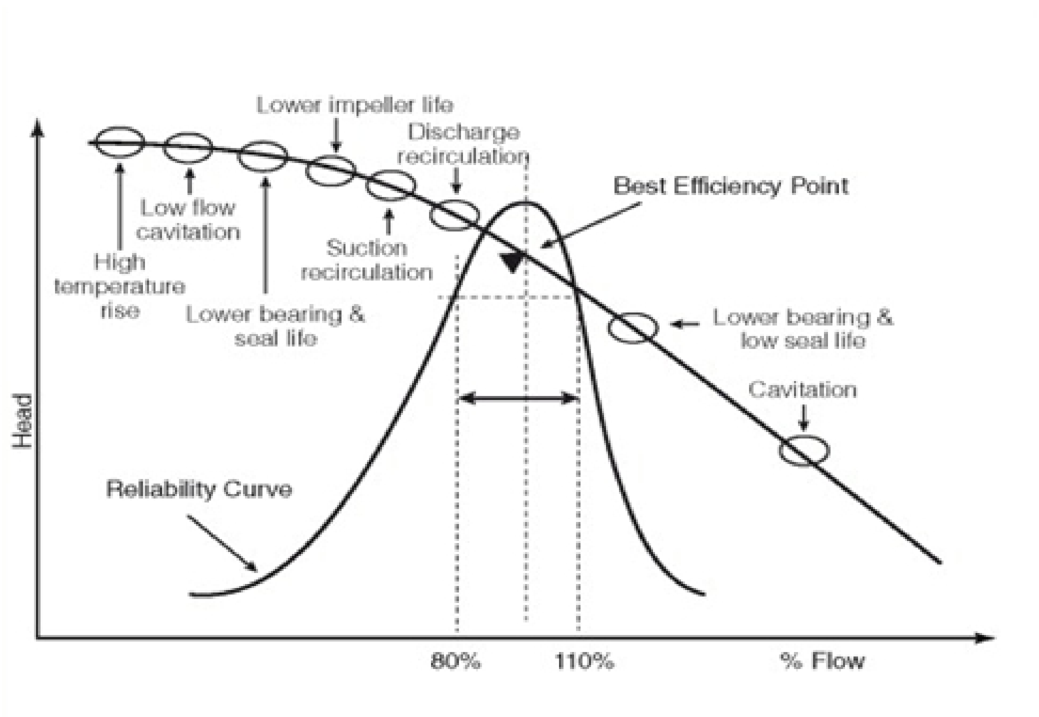


Figure 3.7. Pump reliability and performance curves *(Image from Bloch (2011))*

short since energy usage is a continuous event during uptime. Furthermore, operation energy costs are monitored by the energy supplier, and so data on energy cost savings can be easily calculated. This has been demonstrated by case studies in the waste water industry where customers have seen evidence of energy cost savings within months of installing new energy efficient pump systems (Sulzer Ltd, 2012a).

All companies are interested in cost saving since it leads to increased profits. However, the most appealing method of cost saving for each individual company may vary. Hence it is important to sell the value of 'reduced life cycle costs' through the right service (Figure 3.8). The focus of condition monitoring is to maximise plant reliability in order to minimum downtime and loss of production. This is most appealing to applications where the cost rate of downtime is high, or costs associated with safety and unexpected failures are high. Chemical processing and oil and gas are example industries that may have such applications. In contrast, applications that favour minimisation of energy costs may prefer energy monitoring. This may be the case for industries that complete in energy trading or have high energy costs. Power generation and water pumping are examples of such industries. Other process industries may not have a particular preference for condition monitoring or energy monitoring and may desire some mix of the two.

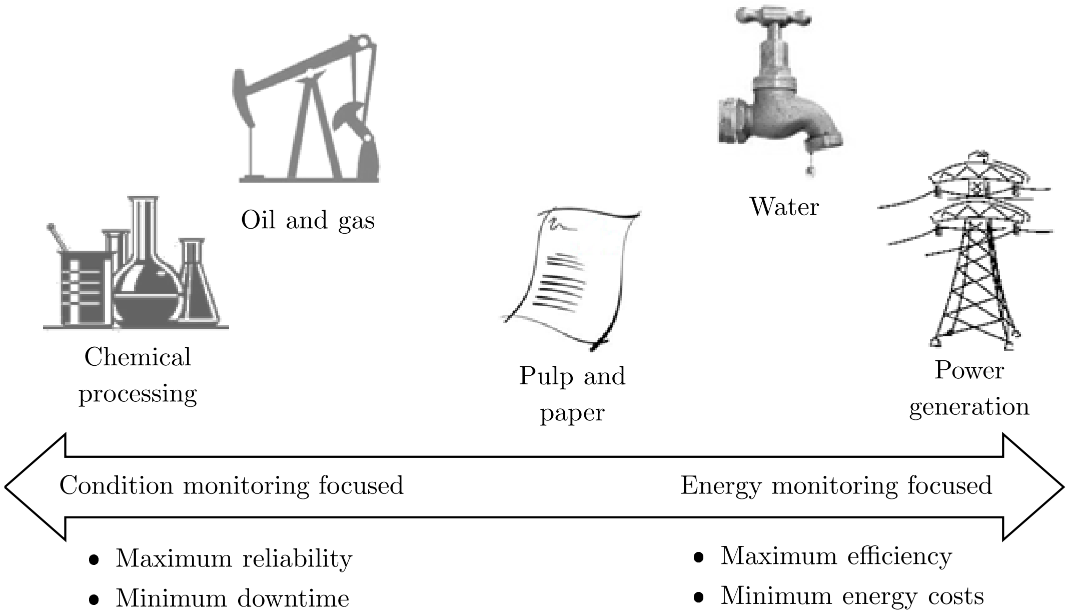


Figure 3.8. Suggested preferences of industries to condition monitoring or energy monitoring

3.13 The Value of Machine Monitoring

For a business, the decision to invest in machine monitoring equipment can be difficult. Moreover, for a supplier to sell machine monitoring systems, the value of these systems must be clearly conveyed to the customer. This can be a difficult task, especially for predicative maintenance systems since the system value lies in the predication of probability of future events. Each prediction has an associated uncertainty, and hence, so does its value.

3.13.1 Evaluating the Value of Predictive Maintenance Benefits

The true value of any failure prediction can only be found by waiting until that failure occurs. By doing this (run-to- failure strategy, see Section 3.3) the value of the prediction is lost. So, when action is taken according to recommendations from a predictive maintenance system, the value of the prediction is often equated to the difference between an estimated cost for an unplanned breakdown and the actual cost of maintenance incurred by performing the predicted maintenance. Hence, uncertainty in this value calculation stems from uncertainty in the estimated cost of an equivalent unplanned failure of the machine.

To address this issue, several structured methods for evaluating the value of predictive maintenance systems have been proposed. For example, DLI Engineering (2013) contributed the formula shown as Equation 3.2 for evaluating the benefits of a predictive maintenance system. Equation 3.2 is expressed in more detail as Equation 3.3 (DLI Engineering, 2013). Similarly, Genesis Solutions published a series of table templates to assist in evaluating the costs, benefits, and return on investment for maintenance improvement projects (Wireman, 2013).

$$\begin{array}{c}\text{Annual}\\\text{benefits}\end{array} = \begin{array}{c}\text{Probability of}\\\text{successful}\\\text{early detection}\end{array} \times \left(\begin{array}{c}\text{Benefit due to}\\\text{decrease in forced}\\\text{outage time}\end{array} + \begin{array}{c}\text{Benefit due to some}\\\text{forced outage time}\\\text{becoming scheduled}\\\text{outage time}\end{array} \right) \tag{3.2}$$

$$\begin{aligned} B = & P_s[c_f t_f f_1 + c_s t_s + c_f t_s (1 - f_1) - c_s (t_s + f_2 t_f (1 - f_1)) \\ & + c_f (t_f (1 - f_1)(1 - f_2))] \end{aligned} \tag{3.3}$$

where:

B	-	Annual benefits [$ per unit year]
P_s	-	Probability of successful early detection (Minimum of 0.5)
c_s	-	Cost of scheduled outage [$ per hour]
c_f	-	Cost of forced outage [$ per hour]
f_1	-	Fraction of forced outage time which is eliminated (Conservatively assume 0.2)
f_2	-	Faction of remaining outage time which becomes scheduled outage time (Conservatively assume 0.2)
t_s	-	Current scheduled outage time [hours per year]
t_f	-	Current forced outage time [hours per year]

3.13.2 Return on Investment

Genesis solutions have published a method for estimating return on investment (ROI) that is specific to investments in maintenance improvement programs48. The method uses several tables to evaluate the possible cost savings of a proposed maintenance program and the cost of the maintenance program itself. These values can then be used to calculate the potential ROI for the proposed project with Equation 3.4. Alternatively Estes (2007) argues that ROI is inappropriate for evaluating the value of cost saving programs and suggests that the term savings on investment (SOI) should be used. In contrast to ROI, SOI should represent all benefits, financial and otherwise, from a value adding programs.

$$\text{Return on Investment} = \frac{\begin{array}{c}\text{Total estimated savings with the}\\ \text{maintenance improvement program}\end{array}}{\begin{array}{c}\text{Total project cost for maintenance}\\ \text{improvement program}\end{array}} \tag{3.4}$$

3.13.3 Return on Assets

Return on assets (ROA, Equation 3.5) is a key corporate measure used for justifying the purchase of assets (U.S. Department of Energy & the Hydraulic Institute, 2006). ROA describes how much net income a company generates relative to the value of its assets.

Hence, ROA is a measure of asset productivity.

$$\text{Return on Assets} = \frac{\text{Net income}}{\text{Average total assets}} \tag{3.5}$$

3.13.4 Return on Asset Reliability

Traditionally asset management was based on capital replacement. However, during the economic downturn of 2008-2009, managers began to evaluate asset productivity and reliability more critically in order to remain competitive in the marketplace. This led to new asset management strategies, and new metrics for evaluating asset performance.

One new metric developed by GP Allied LLC (2009) is the Return on asset reliability (ROAR, Equation 3.6 (Wikoff, 2012)). GP Allied claim that ROAR can be used for evaluating the impact of asset related losses and process losses. Mean time between failures (MTBF) is a simple measurement that quantifies reliability. Obviously, the longer a component stays in service without failing, the more reliable the component is. Overall equipment efficiency (OEE) equates to the product of machine availability, quality of output and machine speed (Equation 3.7). Increasing either of these variables will increase the OEE.

$$\text{Return on Assets Reliability} = \frac{\text{Recovered net income} + \text{Net income}}{\text{Average total assets}} \tag{3.6}$$

$$\text{Overall Equipment Efficiency} = \text{Availability} \times \text{Quality} \times \text{Machine speed} \tag{3.7}$$

3.14 Summary

In this chapter, the reduction of equipment life cycle costs of was identified as the motivation behind machine monitoring. The two machine monitoring subcategories, condition monitoring and energy monitoring both endeavour to achieve this goal but approaching the challenge from two different angles. Condition monitoring predominantly focuses on reducing life cycle costs through minimising operating costs, maintenance costs and costs associated with loss of production due to downtime. Alternatively, energy monitoring focuses on life cycle cost minimisation through managing energy costs. Although these two methods reducing life cycle cost focus on different cost contributors they are not independent since efficient operation of equipment is also associated with low wear rates and equipment reliability.

General factors affecting the adoption of machine monitoring practices in industry were mentioned to provide background on machine monitoring market drivers. Sulzer's experience in entering the condition monitoring and energy monitoring markets was also mentioned. These experiences demonstrated that although Sulzer has developed competitive machine monitoring solutions in the past but failed to efficiently profit from them.

There are a large number of factors that will affect a customer's decision to invest in machine monitoring. Moreover, once decided to invest there are a large number of possible solutions to chose from, each with their respective merits. Hence to successfully profit from machine monitoring it is most important to properly understand customer needs and to pair them precisely with appropriate solutions. Due to Sulzer having limited experience with machine monitoring, and customer needs varying between market segments, it is important that Sulzer focuses its machine monitoring activities in the most appropriate market segments to maximise its probability of commercial success.

The following work presented in Chapter 5 and Chpater 6 identifies the most attractive market segments to Sulzer Pumps for machine monitoring business. Subsequent research presented in Chapter 7 identifies specific market subsegments where Sulzer is suggested to enter with machine monitoring offers.

Chapter 4

Business Model Innovation Theory

4.1 Business Models and Innovation

As defined by Osterwalder and Pigneur (2009), "A business model describes the rationale of how an organisation creates, delivers, and captures value". It is the strategy or logic behind how a company intends to make money. Traditionally many companies have focused their innovation efforts on improving products and processes. These types of innovations often require significant resources, and had significant uncertainty associated with returns. Hence, many businesses now prefer to change the way they do business rather than changing their products or services (Amit & Zott, 2012). This is known as business model innovation.

An innovative product that is set into a good business model is much more difficult to compete with in the market and will have a longer life cycle. Moreover, even when resources are scarce, business model innovation can exploit opportunities to boost revenue streams or reduce costs leading to improved profitability. Hence, business model innovation should be used to complement if not substitute product innovation depending on the objectives of a company.

In the current study, the method of business model generation of Osterwalder and Pigneur (2009) is applied. Other innovation theory is also considered, but the approach of Osterwalder and Pigneur forms the main structure of this case study. In the following sections, Osterwalder and Pigneur's method for business model generation and business model validation are explained. Later this theory is applied to generate concept business models for Sulzer in Chapter 8.

4.2 Business Model Generation with the Business Model Canvas

The Business Model Canvas (Figure 4.1) is a tool developed by Osterwalder and Pigneur (2009) for efficiently generating concept business models. It works by getting the user to identify details of a business model and sorting them into nine key areas. These nine building blocks cover the four main areas of business: customers, offer, infrastructure, and financial viability (Osterwalder & Pigneur, 2009), and allow the user to better visualise, justify, and adjust the business model dynamics. Each of the nine categories on the business model canvas is briefly introduced in the following subsections.

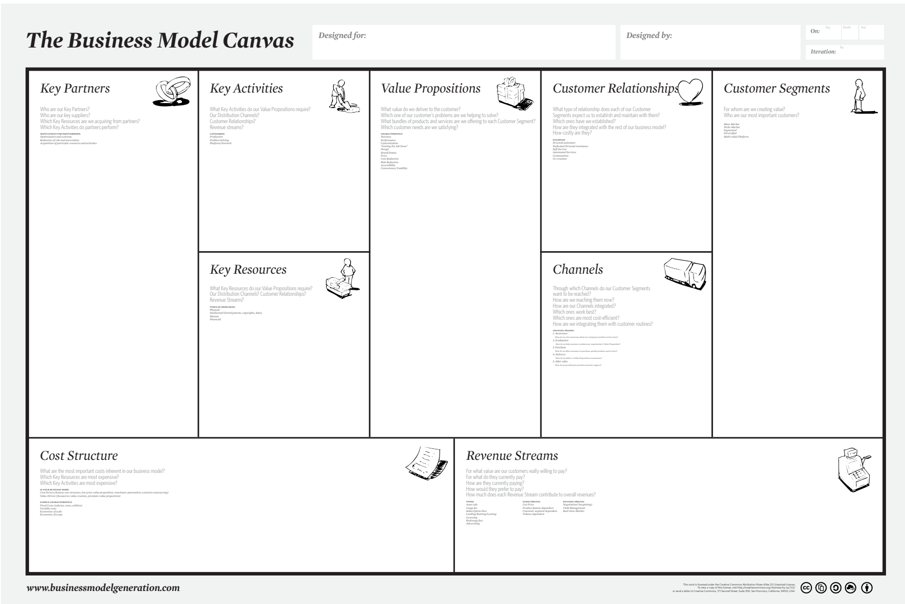


Figure 4.1. The business model canvas (Osterwalder & Pigneur, 2009)

4.2.1 Customer Segments

The first and most important building block of a business model in the customer segments category since this is the source of a profitability. Without customers a company has no source of income and so can not survive. Separate customer segments should be defined for each customer having a distinctly different way of interacting with the company.

4.2.2 Value Propositions

A value proposition is a package of products and/or services that a company offers to its customers. This is the second most important building block since it is what attracts the customer attention to the company. The value proposition should satisfy customer needs in such a way that it turns customer attention towards the company and away from competitors.

4.2.3 Channels

The channels category details the means used to interface with the customer. This includes the method for delivering value to the customer, but also includes methods of communication with the customer. Strategies for marketing, logistics and customer service will all fall into this category to provide a picture of the customer's experience the company is creating. To further define channels, each channel that is indentified should fall into one or more of the five channel phase:

1. **Awareness:** Creating customer awareness of the company
2. **Evaluation:** Helping customers evaluate the company's value proposition
3. **Purchase:** The ways to customer may purchase value from the company
4. **Delivery:** How the value is delivered to the customer
5. **After sales:** Means of providing after sales support to customers

4.2.4 Customer Relationships

The customer relationships building block specifies the type of relationship the company plans to establish with the customer. This is very important for customer development (see Figure 4.8), i.e. customer acquisition and customer retention, which lead to sales growth.

4.2.5 Revenue Streams

Once the customer segments, value proposition, channels and customer relationships have been identified, the company revenue stream may be evaluated. This is more than just financial estimates. The revenue streams building block should contain details on mechanisms that will affect the pricing of the value proposition, and how customer should pay, i.e. one off payment, subscription fees, licensing, etc.

4.2.6 Key Activities

Key activities are required actions that must occur in order to offer value propositions to customers. These activities may fall into categories such as production, problem solving, or platform and network development.

4.2.7 Key Resources

Key resources are what allow the company to offer the value proposition. These resources may fall into categories such as financial, intellectual, physical, or human resources.

4.2.8 Key Partnerships

Key partnerships are strategic alliances that the company will have with other non-competitors. There are many reasons why a company would establish strategic partnerships. These motivations should be outlined in the partnerships building block along with details planning the company's relationship with these key partners.

4.2.9 Cost Structure

The cost of the creating and delivering the value proposition is defined throughout the key resources, key activities, partnerships and channels building blocks. In the cost structure building block these costs are summed up and strategies for minimising costs may be identified.

4.3 The Business Model Environment

Although a business model sufficiently details how a business is designed internally, it does not provide insight on how the business will react to external forces such as market growth, technology adoption trends, market competition and market size. Osterwalser and Blank (2011) call these external forces on a business model 'the business model environment'. They also group external forces into the four categories: market forces, industry forces, trends and macro-economic factors (Figure 4.2). These categories of external forces are defined in the subsequent subsections.

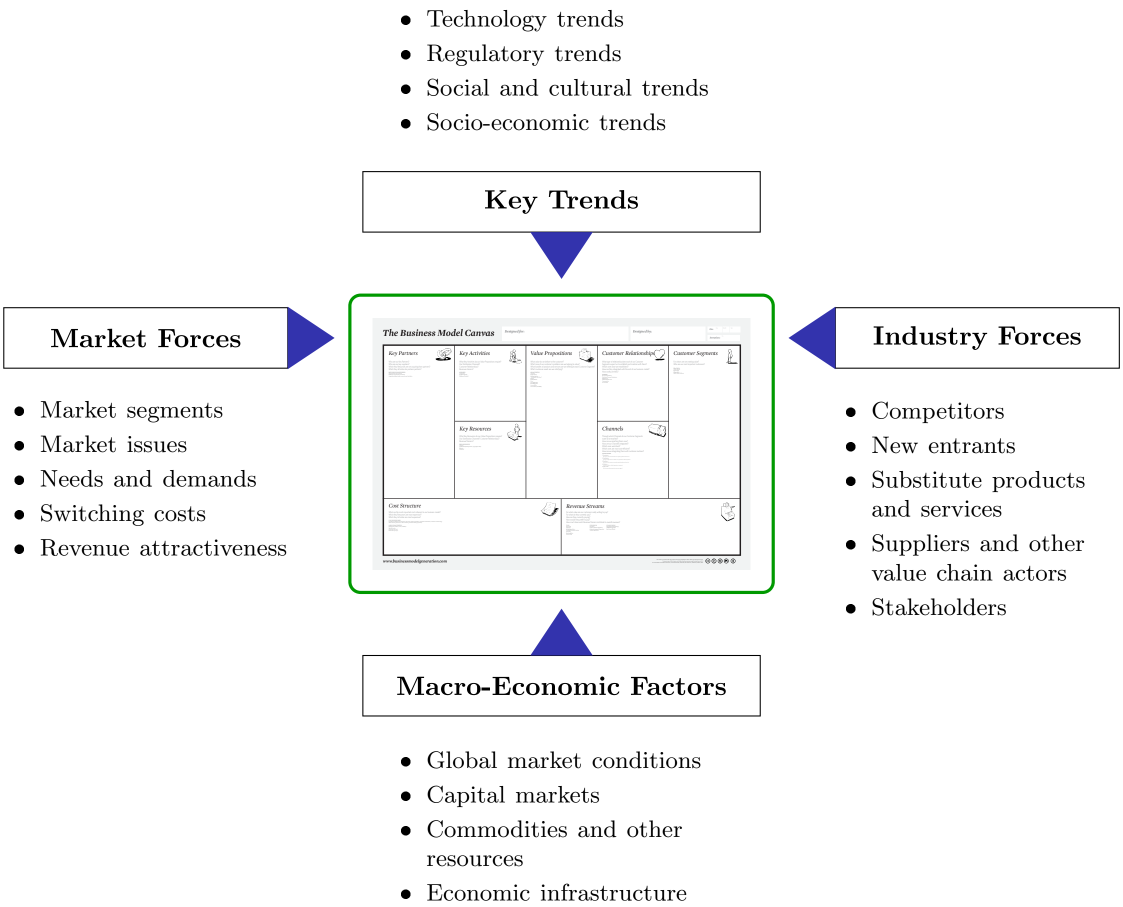


Figure 4.2. The business model environment

4.3.1 Market Forces

Market forces describe the drive behind the target market. Market forces are defined by quantities and qualities such as customer needs, the size of the customer base, the buying power of customers, customer accessibility, and product switching costs for customers.

4.3.2 Industry Forces

Industry forces stem from changes of market actors. For example, industry forces could originate from changes in: the number of competitors in the market, the existence of substitute products or services, or changes of a partner company.

4.3.3 Trends

Different business environment trends can have a significant effect on the functionality of a business model. It is important to recognize environmental trends in order to predict future business environments and to plan to adapt the business model. Trends that may affect a business model could appear in areas such as technology development, social and cultural development, industry preferences, or microeconomic factors.

4.3.4 Macro-Economic Factors

Macroeconomic factors such as national and international market conditions should be identified as they may significantly affect the business model. These factors could include changes in government regulations, law, industry standards, employment policy, etc.

4.4 Value Proposition and Customer Segment Pairs

The order in which the business model canvas is completed is important to building a successful business model. Arguably the 'value proposition' and 'customer segment' blocks form the foundation of a business model and deserve special consideration. It is very important that these two building blocks have a good fit with one another as this creates the drive behind the entire business model. For example, a value proposition that is not perceived as valuable by the target customer segment will not result in a healthy customer demand, and so other aspects of the business model (such as the channels for delivering value) become irrelevant.

In order to properly fit a value proposition with a customer segment Osterwalder offers the 'value proposition canvas' (Figure 4.3) as a tool to be used in conjunction with the business model canvas. The value proposition canvas magnifies the value proposition and customer segment blocks on the business model canvas for closer inspection and reveals key points to consider within each.

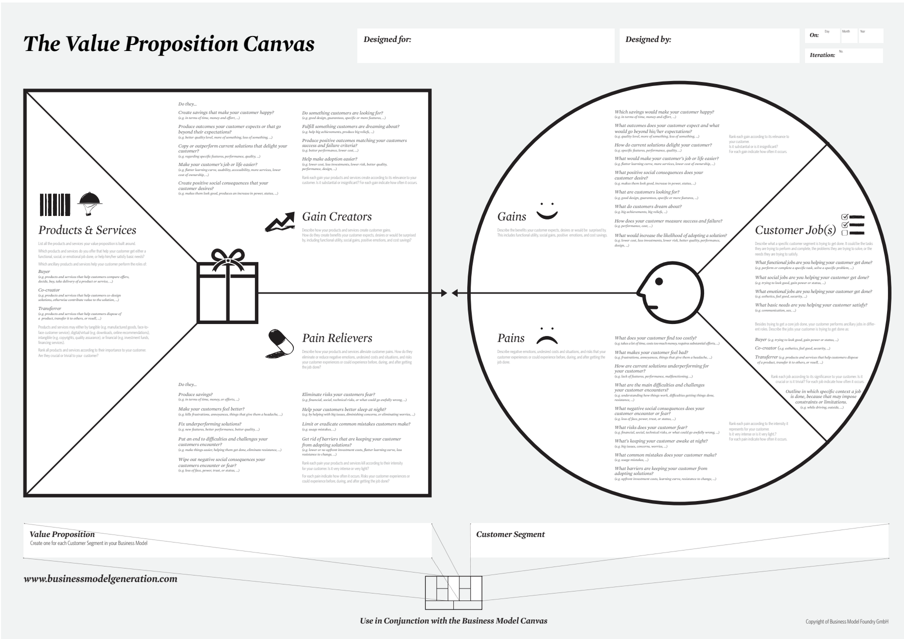


Figure 4.3. The value proposition canvas (Osterwalder, 2012)

4.5 Alternatives Business Model Communication Tools to the Business Model Canvas

Several authors have developed alternative tools for communicating business models, some of which are based on business model canvas of Osterwalder and Pigneur (2009). Some of these alternative business model structures are:

- The Lean Canvas developed by Maurya (2010) (Figure 4.4)

- The Business Model Canvas Revisited developed by van Wingerden (2011) (Figure 4.5)
- The Go-To-Market Canvas developed by Explorics Company (2012) (Figure 4.6)
- The Value Envelope developed by Kraaijenbrink (2013) (Figure 4.7)

A common motivation behind alternative business model tools has been dissatisfaction with the business model canvas of Osterwalder and Pigneur (2009). Different degrees dissatisfaction have led several authors to either adapt Osterwalder and Pigneur's business model, or to create a significantly different business model communication tool canvas to suit their own needs. Figure 4.4 to Figure 4.7 show some alternative tools for communication business models.

4.6 A Business Generation Process

The first steps toward new business generation involve identifying opportunities and conceiving ideas for business around these opportunities (Figure 1.3). Next, in order to design strong competitive business models it is recommended that the designer have a good understanding of the business model environment (Osterwalder & Pigneur, 2009) (see Section 4.3) as it defines the external constraints around the business model. In addition, analysis of market forces will aid in identifying customer segments for which value propositions can be defined (see Section 4.4). These value proposition and customer segment pairs will form the basis of a business model.

Figure 4.8 shows the process from Osterwalser and Blank (2011) for creating, validating and executing business models. The first step in this process is to generate concept business models (see Section 4.2). Secondly, these concepts must be evaluated to identify the most preferable model. At this stage it is important to remember that a business model is merely a hypothesis for the structure of a future business. Hence before the business model can be used it must be validated through the customer development process (Figure 4.8). This involves discovering new customers, approaching them, and validating that they are interested in the value proposition (see Section 4.2.2) Furthermore, they must be willing

Figure 4.4. The Lean Canvas developed by Maurya (2010)

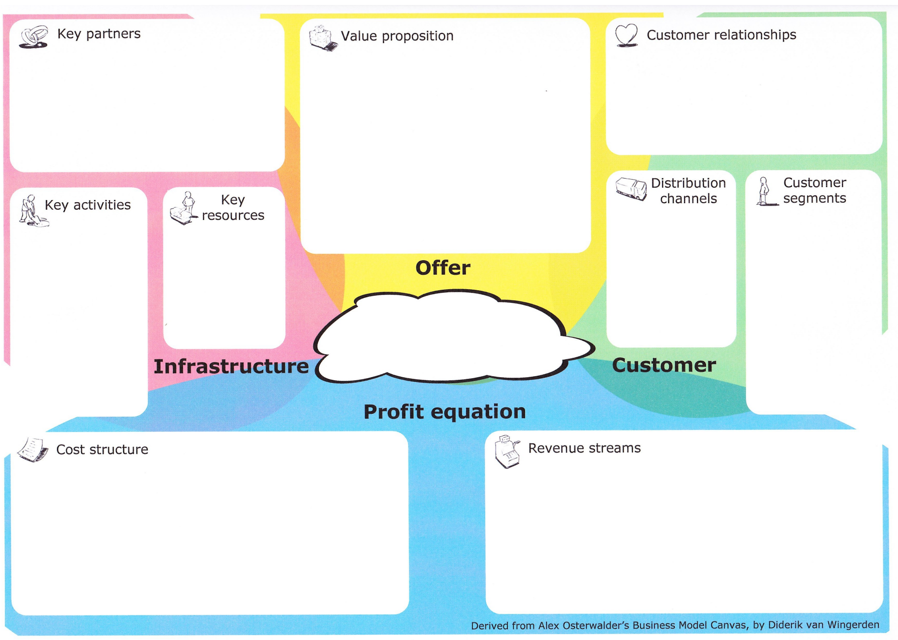


Figure 4.5. The Business Model Canvas Revisited developed by van Wingerden (2011)

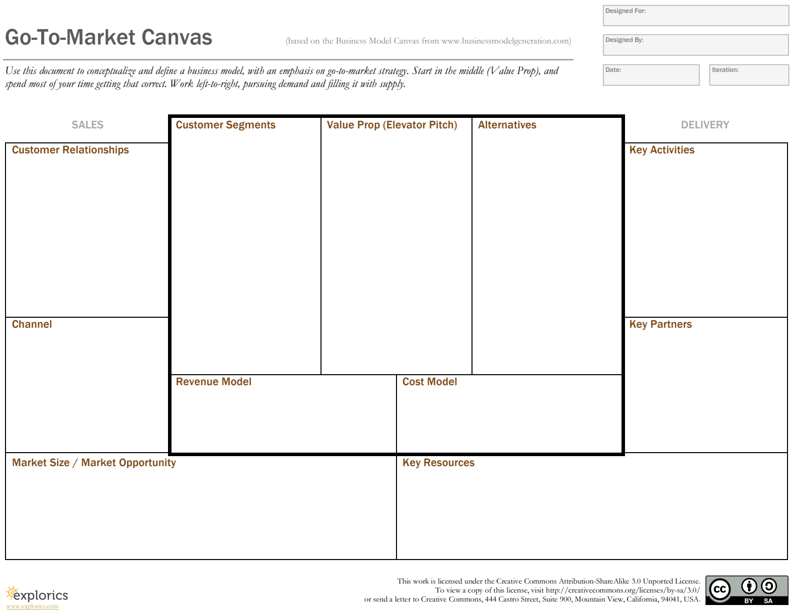


Figure 4.6. The Go-To-Market Canvas developed by Explorics Company (2012)

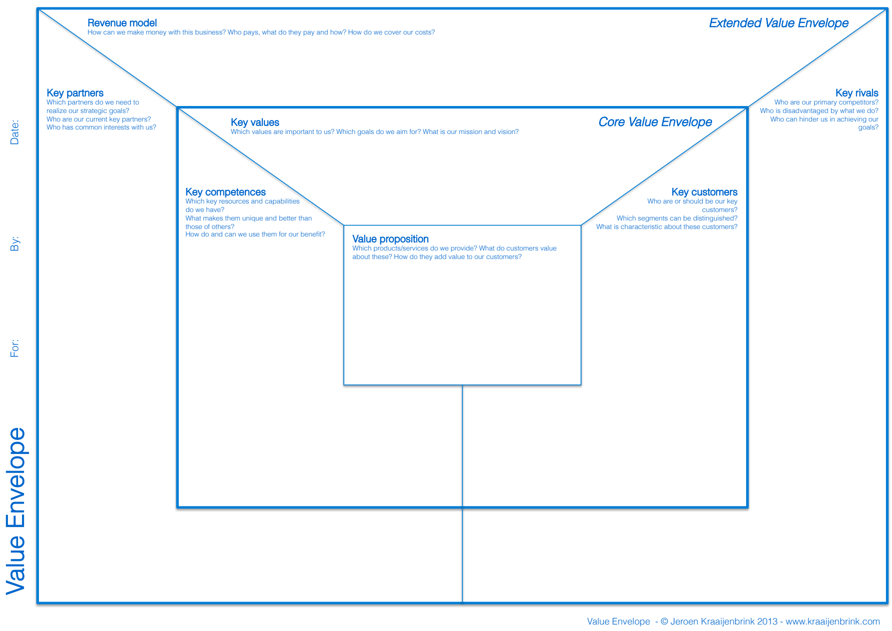


Figure 4.7. The Value Envelope developed by Kraaijenbrink (2013)

to pay for the offered value. Only once the business model has been proven viable it may be executed.

Finally, once a business model has been developed, measures to protect it from competitor imitation should be built in (Figure 4.8). This can be done through protecting intellectual property associated with the business. However, incorporating novel functions within the business model is seen as a stronger form of protection.

4.7 Strategies for Business Model Innovation

Amit and Zott (2012) suggest that the four major factors that drive value in business models are: novelty, lock-in, complementarities, and efficiency. Novelty ensures that a business model distinguishes a company from its competition. Lock-in refers to the aspect of a business model that encourages customers to remain engaged in business with a company. Complementarities refer to interdependencies between businesses that have the effect of mutual value gains. Efficiency describes cost saving through interconnecting activities within a business model.

4.7.1 Focus on Key Activities

Amit and Zott (2012) stated that successful business model innovation is often achieved through adequately modifying business activities in one of three ways. The first is by adding novel activities to a business model, i.e. changing the activity content. Secondly, a business model can change by linking existing activities in a novel way to change the activity structure. Thirdly, changing the parties that perform key activities may significantly affect the model through a change in governance. Amit and Zott (2012) also suggest that the following six questions should be asked before launching a new business model:

1. What customer needs will the new business model address?
2. What novel activities could help satisfy those needs? (business model content innovation)
3. How could the activities be linked in novel ways (business model structure innovation)

4. Who should perform the activities? What novel governance arrangements can be found? (business model governance innovation)
5. How will value be created for each stakeholder?
6. What revenue models can be adopted to complement the business model?

Note that half of these questions (2 - 4) address how the business activities have been changed, emphasises the importance of the 'key activities' building block on the business model canvas (Section 4.2.6). The remaining questions address how the activities changes affect value creation and revenue streams.

4.7.2 Business Model Security

Innovative products can be reverse engineered and brought to market by competitors, reducing the value in the original product. This is much harder to do when the novel design of a product makes it inherently difficult to copy. Similarly, as business models may be imitated by competitors, designing a novel business model can increase the security of a company's business. Teece (2010) suggests that this can be done in the final stages of business model design by devising 'isolating mechanisms' to protect the business model (Figure 4.9).

4.8 Past Sulzer Pumps Business Plans

4.8.1 An Analysis of the 2003 SmartMonitor Business Plan

The business model canvas in Figure 4.10 and the business model environment in Figure 4.11 summarise the 2003 SmartMonitor investment memorandum and business plan (Bjønness, 2003). This plan describes the rational behind the SmartMonitor business in order to attract an investment of 1.5 million CHF. Throughout the business plan a strong confidence in the capabilities of SmartMonitor technology is conveyed. However, selling the technology proved difficult. Around mid 2003 Sulzer lost interest in SmartMonitor and committed to divesting in the technology (Sulzer Ltd, 2003).

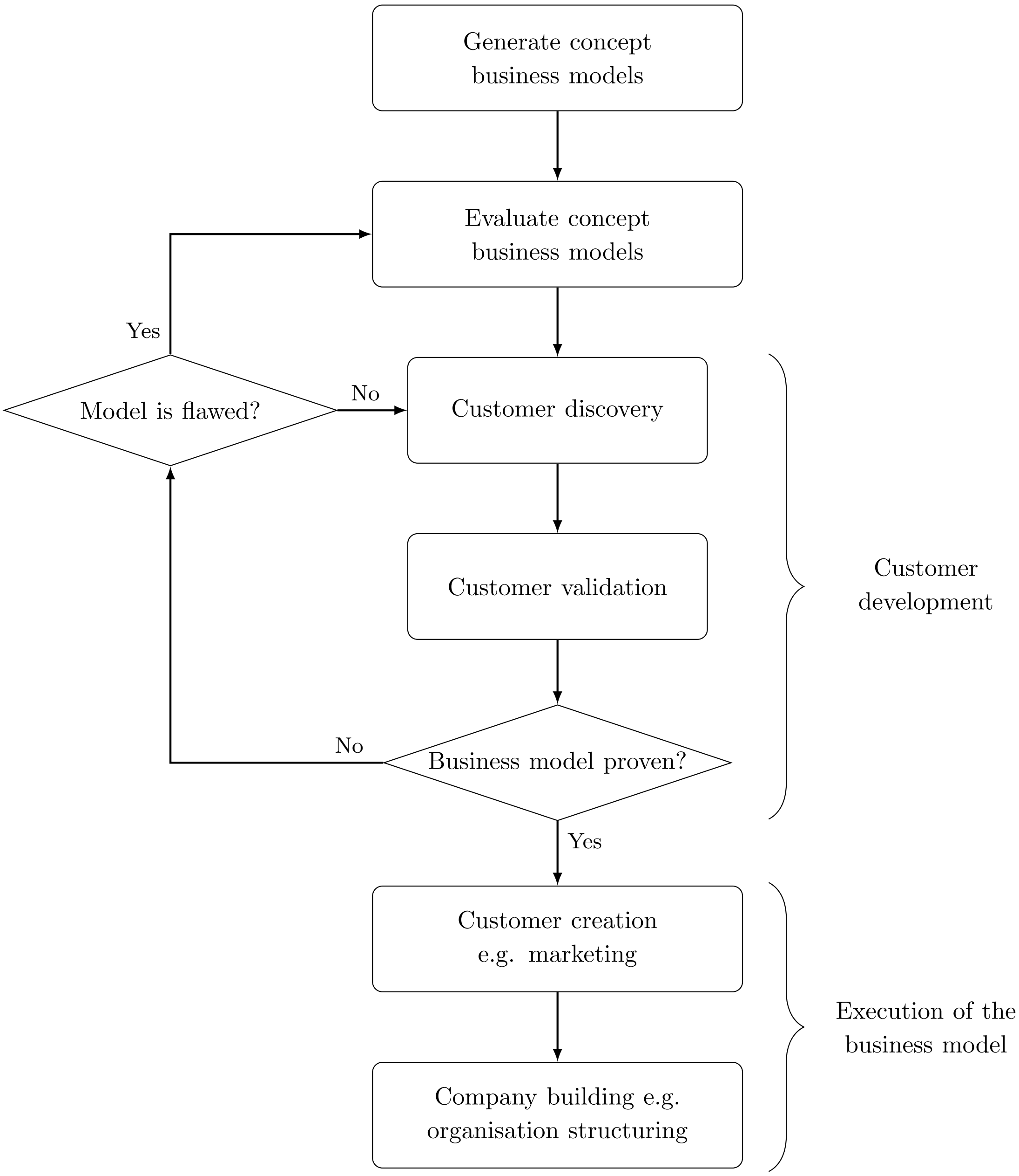


Figure 4.8. A business generation process of Osterwalser and Blank (2011)

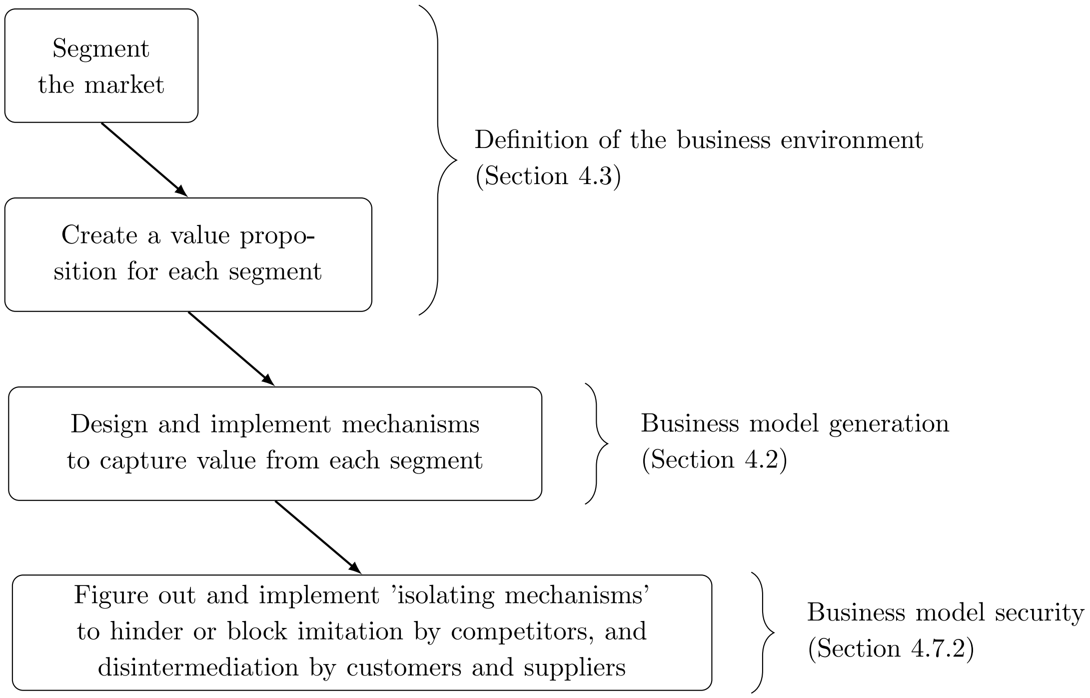


Figure 4.9. Steps to achieving a competitively sustainable business models (*Source: Teece (2010)*)

From reviewing the SmartMonitor business plan it appears that the value of SmartMonitor was primarily in the technology sophistication. Three patents were used to protect SmartMonitor technology in addition anti-piracy protection. However, no methods were used to avoid substitutions of SmartMonitor. Moreover, the SmartMonitor Business Plan SWOT analysis recognises engine OEMs as a threat. However, few actions to minimise the threat were suggested. Eventually engine OEMs created there own solution, reducing market demand for SmartMonitor. This emphasises the importance of business model security (see Section 4.7.2).

4.8.2 An Analysis of the IntO Business Plan

IntO was arguably not an innovative product but an engineered product. This is emphasized by the IntO business plan presentation of 2006 (Sulzer Ltd, 2006b) which focuses on engineering specifications and cost calculations but has very little content justifying how the IntO benefits the customer. Figure 4.12 is the business model canvas based on this

Key Partners

Critical Suppliers:

- National Instruments (LabVIEW)
- Sulzer Innotec

The first SmartMonitor patent rights were shared between:

- VA Tech
- MAN Turbo
- Burckhardt Compression
- Sulzer Pumps

SmartMonitor trials were also done with:

- SR Technics
- Crossair
- Air France
- ABB Turbo Systems
- MTU

Key Activities

- Software development
- Decision support system development
- Trialling SmartMonitor with potential customers

Key Resources

- 3 SmartMonitor patents
- Central monitoring centre where data is processed
- Development engineers
- Sales and marketing staff
- Investment capital

Value Proposition

- Maintenance cost savings through predictive maintenance, i.e. better maintenance scheduling
- Downtime cost savings through fast machinery fault detection Methods for adding value:
- Remote data acquisition from sensors installed on equipment
- Health monitoring with fault diagnostic support for equipment
- Equipment useful remaining life predictions
- Decision making tools: Decision Support System (DDS)
- Cost optimisation tools

Customer Relationship

- Web interface where customers can log on to monitor their assets

Channels

- SmartMonitor can run at a central location or locally under license (either on a PC or embedded system)

Customer Segments

- Aviation OEMs
- Aircraft owner operators
- Maintenance and repair organisations
- Jet engine leasing companies
- Insurance companies
- Power station operators
- Refinery operators

Cost Structure

- Little or no cost structure detail was provided in the business plan
- The goal of SmartMonitor was to provide customers with savings 5 to 7 times larger than there expenditure on SmartMonitor (i.e. SOI of 500 % - 700 % for customers)
- EBIT in 2002 was -855k CHF. This expense was financed by Sulzer
- EBIT in 2003 was budgeted as -794k CHF. Combined with the budgeted -937k CHF net operating cash flow and the CAPEX budget of 50k CHF, the SmartMonitor team was searching for 1000k CHF of funding to establish SmartMonitor Company

Revenue Streams

- Price of SmartMonitor is charged per hour of machine monitoring
- Licence fees for de-centralised monitoring
- Pricing plans were not fully developed and flexible with the customer situation
- Gross sales for 2002 were 120k CHF
- Gross sales budget for 2003 was 1000k CHF
- A positive net operating cash flow was projected for 2005

Figure 4.10. The business model canvas for SmartMonitor based on the 2003 business plan (Bjønness, 2003)

Industry Forces

- Competitors

  1. Engine OEMs
  2. Operator's own IT division
  3. Independent software developers

- Sulzer was the 100 % owner of SmartMonitor
- Required partner to invest in SmartMonitor for it to become its own entity
- Few OEMs had technology as advanced as SmartMonitor. Tools that were available were not as user-friendly as SmartMonitor

Market Forces

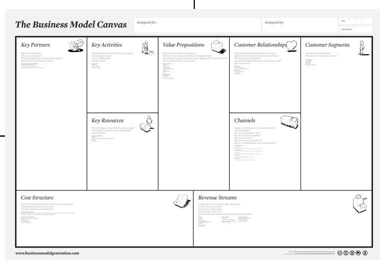
- Market segments

  1. Aviation
  2. Power generation
  3. Processing plants

- Growing machine populations and decentralisation of fleets in these market segments is increasing demand for asset management and monitoring systems
- Customers demand:

  1. Cost optimisation tools
  2. Cost reductions to provide low cost airline tickets
  3. More sensitive monitoring equipment and intelligent controls to fine-tune engine performance
  4. OEM independent monitoring equipment and services

- Use of SmartMonitor could save customers 10 % of their insurance premiums



Key Trends

- Machinery in the aviation and power industries were becoming increasingly decentralisation while fleet sizes were growing

Macro-Economic Forces

- Grounding of Swissair in October 2001 narrowed local business and development opportunities
- Airline industry "was in crisis". However, long term growth of 5 % - 7 % per annum was expected (Bjønness, 2003)

Figure 4.11. The business model environment for SmartMonitor based on the 2003 business plan (Bjønness, 2003)

business plan presentation. Most of the building blocks have been considered. However, at that stage of the project the cost structure was still being investigated.

Pekka Salmi mentioned that subsequent to the 2006 business plan presentation several technical issues were struck during the development of the IntO device. At this stage the business plan did not progress further. Similarly, development of the IntO business model ceased, leaving the model incomplete and untested. Hence, in the case of IntO, no apparent fault in the business model could be identified since the model was only at a concept stage and had not begun the validation procedure (see Section 4.6). Business model validation is an important step in proving a business models functionally and capacity to generate and capture value. Hence it is recommended that future ventures have a well planned and executed business model development schedule to ensure that business model developments and validation procedures stay on track.

Even though IntO was not deemed a commercial success, Sulzer Pumps gained valuable experience from this venture, particularly in the area of condition monitoring hardware and software development. This is experience will be invaluable for future ventures and should be fully utilised.

4.9 Summary

In this chapter the business innovation theory used for the current research was introduced and used to analyse previous business Sulzer Pumps machine monitoring business cases. Application of the theory to previous business cases provided grounds for discussion on why these past business cases did not succeed. However, definite causes for the failure of past business models could not be identified due to lack of documentation on past projects.

Possible reasons for the failure of the SmartMonitor business model were suggested as 1) a lack of business model security, and 2) a poor understanding of the target customer segment. Suggested reasons for the lack of success with the IntO business venture were 1) a limited understanding of the business model environment, and 2) a poor understanding of the target customer segment needs. In either business case use of the value proposition

Key Partners

Critical Suppliers:

- Sensor suppliers
- Laske - IntO software
- National Instruments LabVIEW
- ActiveFactory

Non-niche suppliers:

- GPRS network carrier
- IT suppliers

Key Activities

- Data monitoring and analysis
- Report generation

Key Resources

- GPRS server + network connection
- Monitoring software
- SQL server
- Analysis software

Value Proposition

- Pump protection through condition monitoring will save maintenance time and cost for customers
- Condition monitoring hardware and software

1. IntO device supply
2. IntO software supply
3. Auxiliary sensor supply

- Three packages levels

1. Diagnostic
2. Remote monitoring
3. Monitoring + analysis

Customer Relationship

- Hardware supplier
- IntO Installation support
- IntO configuration service
- Remote diagnostic services CSS

Channels

- Marketing

1. Product brochures
2. Industry exhibitions

- Hardware delivery and installation services
- Remote connection to customer's data

Customer Segments

- Process pump users
- General industrial pump users

Cost Structure

- Hardware and software for monitoring and analysis at Sulzer €8471 per 50 pumps

Not defined in the presentation but specified as future work:

- Data analysis experts €?/hr
- Report creation and distribution
- Customer support: technical support, decision making, etc

Revenue Streams

- Between €2200 and €5294 per hardware package
- Delivery and installation fees: €78/hr +expenses
- Configuration service: €100/device
- Product monthly rental fees €122 - €295 depending on the package
- Monthly subscriptions to monitoring services
- Potential revenue was estimated based on 150,000 pumps installed world-wide as €17.6m

Figure 4.12. The business model canvas for IntO based on the business plan presentation of 2006 (Sulzer Ltd, 2006b)

canvas may have significantly improved the business models strength.

Chapter 5

Current Customer Demand for Machine Monitoring

5.1 Introduction

The importance of knowing the business environment for business model design was mentioned in Section 4.6. Arguably, one of the most important business environment factors is customer demand as it is a direct driver for successful business. Unfortunately customer demand is far from independent of other environmental factors, which makes it difficult to evaluate. Sulzer customer support service and sales staff are in frequent contact with Sulzer customers and so are arguably the most qualified employees to evaluate customer demand. In this chapter the opinion of Sulzer CSS and sales staff on the present customer demand for machine monitoring is collated and analysed in order to evaluate this important business environment factor.

5.1.1 Objectives

The aim of the work presented in this chapter was to obtain a perspective on the present customer demand for machine monitoring. The gathered data contributes to a view of the present business model environment with a focus on market forces.

5.1.2 Method

Data presented in this chapter was collected via a survey that was distributed Sulzer customer support services and sales staff around the globe. The structure of the survey is presented in Section 5.2 with an explanation for the questions it contained. The survey was hosted online and participants were sent a link to the survey via email. To promote participation in the survey several heads of CSS and sales were asked to distribute the link to employees in their business area. An overview of this distribution chain is shown in Figure 5.1.

5.2 Survey Design

The survey created to evaluate the view of Sulzer staff on customer demand for machine monitoring solutions was designed to address three main topics: 1) the customer's unsolved problems, 2) the customer's present chosen solutions, and 3) the customer's means of measuring solution value. The relevance of these topics is discussed in the following subsections and the final survey questions can be found in Appendix B. In addition to these questions each participant was asked to record what business segments and business area they work in most.

5.2.1 Identifying the Customer's Interests

Question 8 and 9 of the customer demand survey (Appendix B) focused on revealing what problems customers have and the relative importance of these problems. In addition, questions 10 and 16 aimed at identifying the severity of these problems by asking what proportion of customer already have machine monitoring solutions, and how often customers approach Sulzer for solutions. Finally, question 17 asked for Sulzer staff to express what they thought customers needed the most. The overall goal of these questions was to identify the most common customer problems so that Sulzer may focus innovations in these areas. Responses to these questions are presented in Section 5.3.3 (questions 8, 9, 16 and 17) and Section 5.3.4 (question 10).

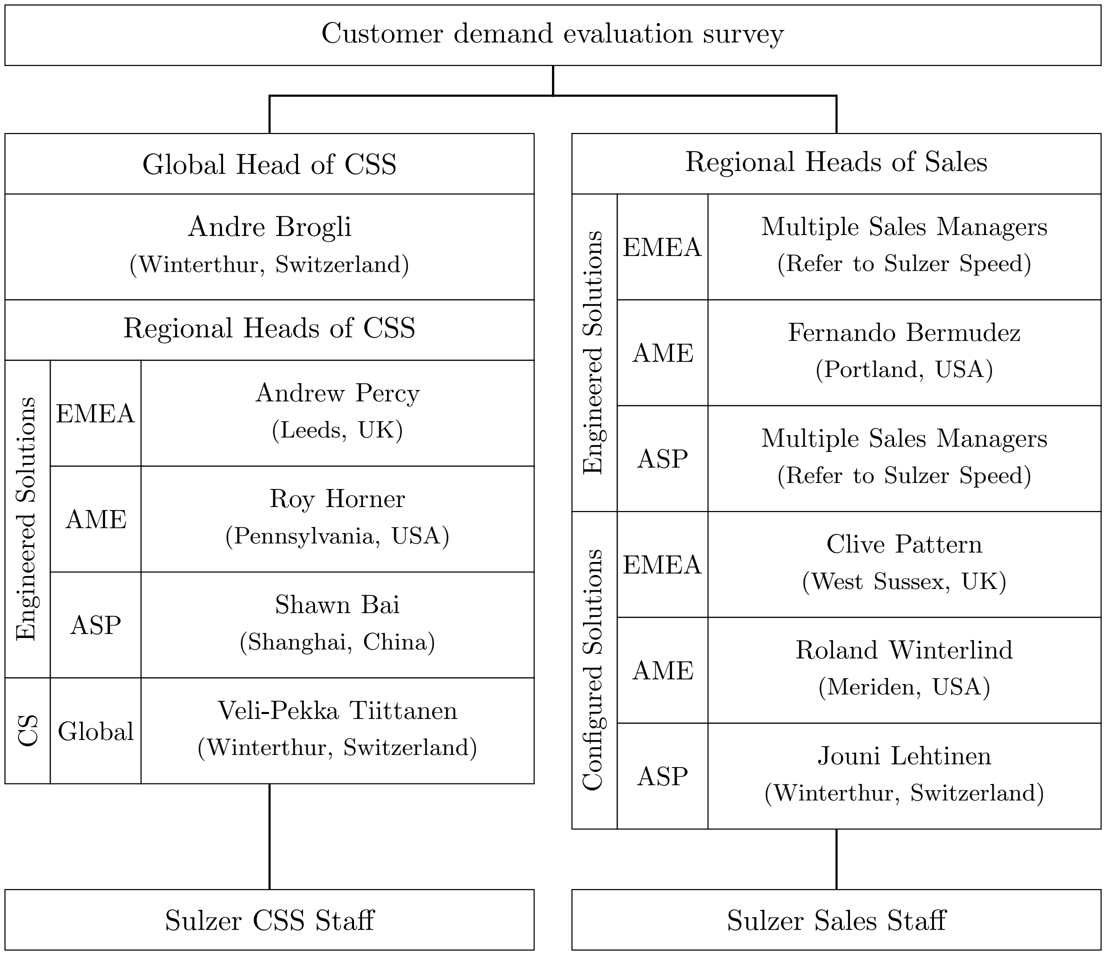


Figure 5.1. Customer demand survey distribution overview

5.2.2 The Customer's Preferred Solution

Questions 11, 12, and 15 of the customer demand survey (Appendix B) focused on identifying present industry forces and customer preferences. These questions inquired what technologies and services were currently popular with Sulzer customers and for what reason they were preferred over other solutions. The results to these questions are presented in Section 5.3.5. Question 13 was included to evaluate whether customers were satisfied with their current solutions and what recent or future solutions they are most interested in. The results of this question are presented in Section 5.3.6.

5.2.3 The Customer's Measure of Machine Monitoring Value

It is critical to understand of how the customer perceives value in machine monitoring solutions to effectively market machine monitoring products or services. Although qualitative arguments for using of machine monitoring solutions are widespread, sound quantitative financial arguments are far less common. This is because calculating the return on machine monitoring investments can be difficult (see Section 3.13). Questions 6, 7 and 14 of the customer demand survey (Appendix B) aimed to identify if customers feel the need to quantify machine monitoring benefits with life cycle cost calculations, and how they would do so. The responses to these questions are presented in Section 5.3.2 (questions 6 and 7) and Section 5.3.7 (question 14).

5.3 Customer Demand Evaluation Survey Results

5.3.1 Participation

The machine monitoring demand survey completed by Sulzer CSS and sales staff was open for five weeks (between 8 April 2013 and 10 May 2013). During this time 143 participants began the survey, but only 93 participants completed it. Participant experience at Sulzer Pumps ranged from less than one year, to in excess of 34 years employment in various roles, business areas and business segments. Figure 5.2 shows the number of survey responses obtained from each business area, and Figure 5.3 shows which business segments participants were involved with. The majority of survey participants worked within two or more business segments (Figure 5.4), including five participants that worked in all five business segments.

Total participation and the participation rate of the current survey greatly exceeded that of the previous internet-based internal survey on machine monitoring by Kisoryo (2011) (93 versus 36 participants, and ~1.0 response/day versus ~2.7 response/day respectively). This is due to inclusion of Sulzer sales staff as well as Sulzer CSS staff. Participation from sales staff in the AME and ASP business areas was particularly exceptional (Figure 5.5), which could have given the survey results a bias viewpoint. However, no such bias was apparent when the survey results were analysed.

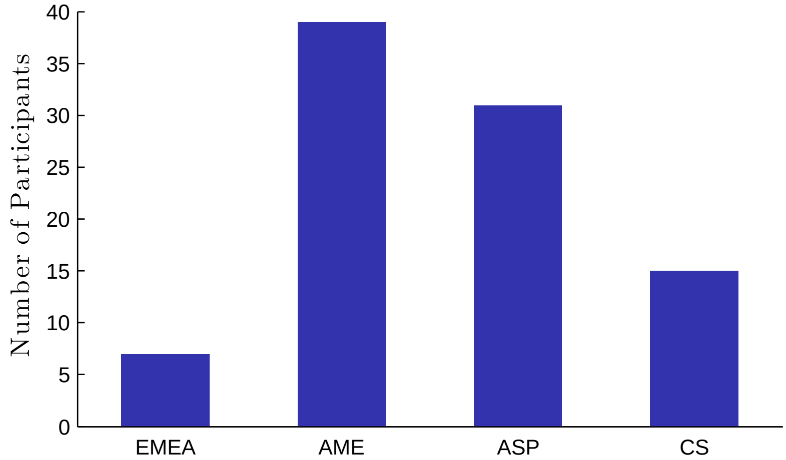


Figure 5.2. Completed customer demand survey responses by business area

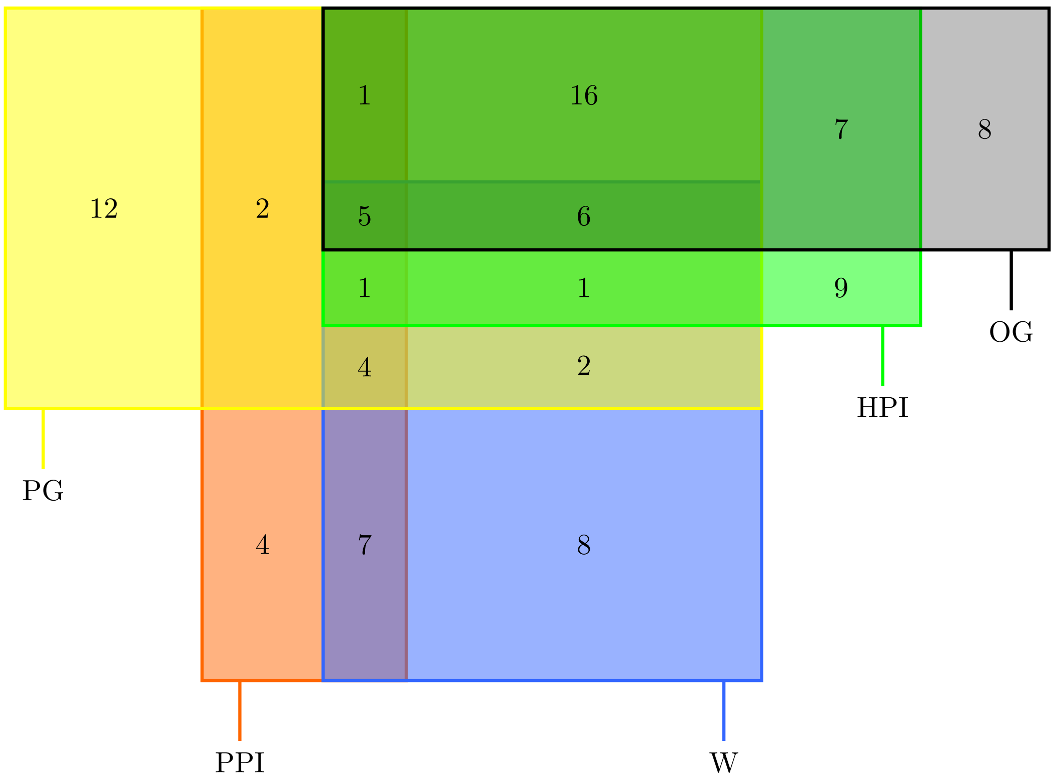


Figure 5.3. Customer demand survey responses by business segment (Not to scale)

Good response rates were achieved when the survey was distributed through the major heads of CSS and sales listed in Figure 5.1. Even better response rates were achieved after

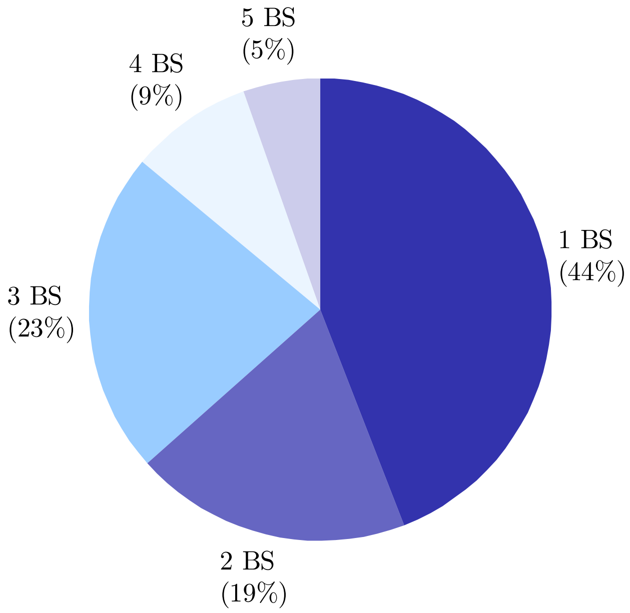


Figure 5.4. The distribution of the customer demand survey participants by the number of business segments they worked in

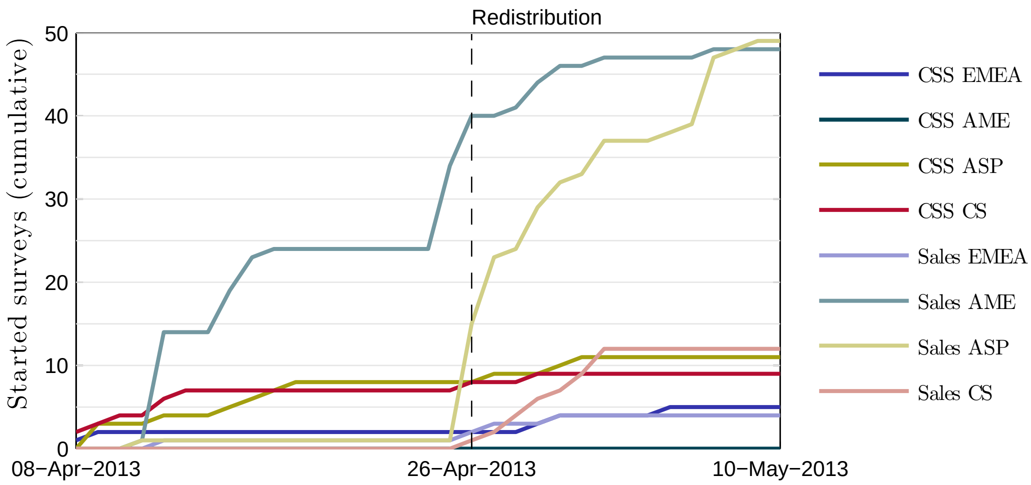


Figure 5.5. Customer demand survey participation rates

the 26th of April when the survey was redistributed (Figure 5.5). The sudden increase in participation rate at this time was also due to the survey being distributed through several engineered solution sales managers in the EMEA and ASP business areas. These business areas did not have a published sales organisation structure tree like other business areas, and so distribution through business area heads was not possible. Instead, the survey was distributed by emailing a link to the online survey to branch sales managers whose contact details were published on Sulzer Speed (see Section 1.7.2).

5.3.2 Sulzer Pumps Customers and Life Cycle Cost Analysis

Life cycle costs refer to the total cost of an asset over its entire lifetime (see Section 3.1). Modelling LCCs may be useful for evaluating and minimising the LCC of an asset, and hence reducing operating and capital expenditure of a business. However, it is not known if this approach is valued by Sulzer Pumps customers. The following results reflect the opinion of Sulzer Pumps CSS and sales staff on whether LCC modelling and minimisation is important to Sulzer Pumps customers.

Figure 5.6 shows that the majority of survey participants (81 %) believe that LCC minimisation is important to Sulzer Pumps customers. However, only 32 % of participants believe that LCC modelling is used by a significant proportion of customers ($> 30\,\%$) (Figure 5.7). Most participants (44 %) believe that less than 30 % of customers use LCC modelling for reducing costs, including 18 % of participants that believe LCC modelling is not used at all. The remainder or participants (24 %) were unaware of customer involvement with LCC modelling.

Several survey participants noted that the LCC of equipment is becoming more and more relevant for customers as market competition increases. Moreover the concept of LCC analysis is becoming increasingly appealing to customers as it allows for better planning and budgeting. However estimates on the proportion of customers currently using LCC modelling had a wide variation depending on industry, equipment application, and geographical region. In general, written responses expressed that customers are primarily concerned with reducing LCCs that contribute to operating expenditure, i.e. costs of energy, operation, maintenance and downtime, since these costs usually dominate the total cost of production. Furthermore, several of these responses noted that the cost of energy is the most significant factor in many industries.

A minority of survey participants suggested that LCC analysis was not seen as important by customers. These responses were predominately (78 %) from participants working

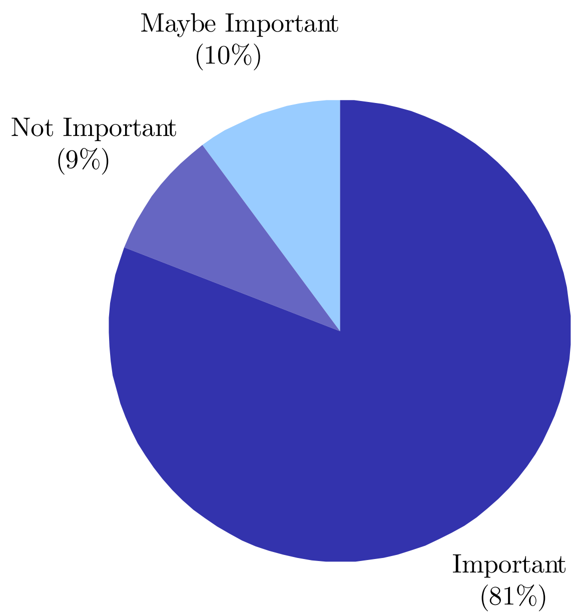


Figure 5.6. Estimated importance of life cycle cost minimisation to Sulzer Pumps customers

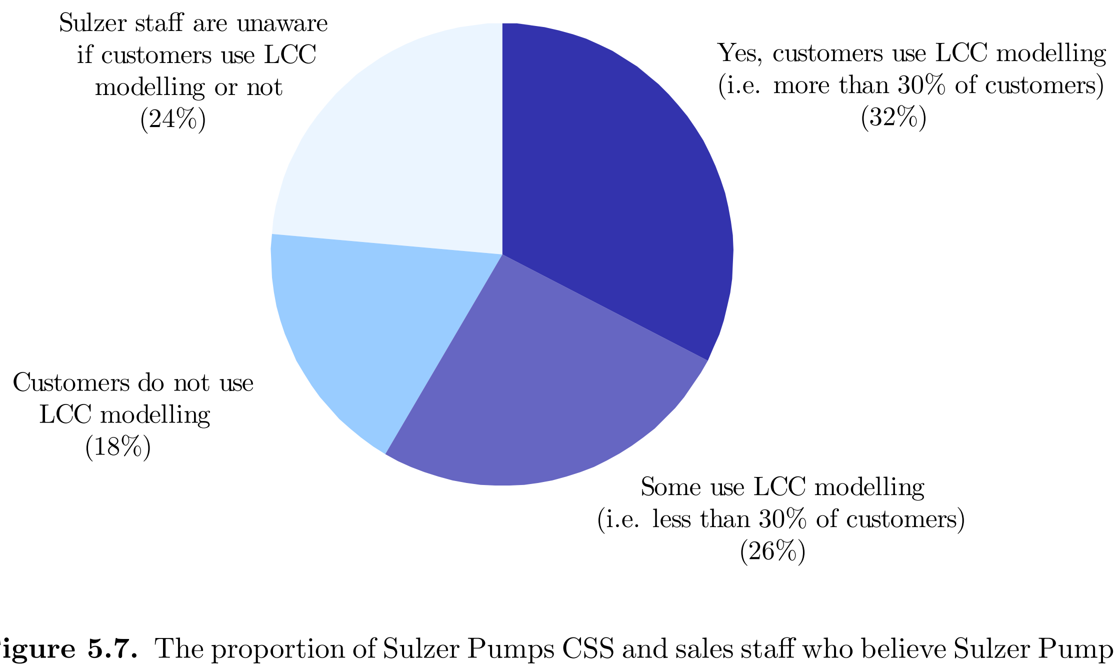


Figure 5.7. The proportion of Sulzer Pumps CSS and sales staff who believe Sulzer Pump customers use life cycle cost modelling

in the engineered solutions markets. Two explanations were provided for customers having a lack of interest in LCC modelling. Firstly, fluctuating costs in India make accurate modelling of LCCs difficult, hence deterring customers from using LCC analysis. Secondly, customers that have no motivation to minimise operating expenditure, such as EPC companies, have little interest in LCC modelling.

Participants from the oil and gas business segment reported that customers (such as BP Company) may require Sulzer to provide a LCC analysis with bids for high energy pump requests. In contrast, some other customers in the oil and gas or hydrocarbon processing segments choose to do their own independent LCC analysis. Several participants noted that LCC analysis was more common in the onshore oil and gas industry, refineries, and chemical processing than in offshore applications.

According to survey responses, LCC modelling for cost saving in the power generation segment is rare. Currently, the main purpose of monitoring in power generation is failure prevention to avoid unexpected outages (i.e. to avoid discontinuity in the power market value chain). LCC analysis of power generation equipment is becoming more relevant as customers seek increases in plant efficiency.

Judging by the current survey results, LCC analysis and modelling appears to be most common in the water industry. Survey participants from all business areas report that these approaches to cost minimisation are used by most municipalities particularly those managing urban areas. Moreover, LCC modelling is most common with new long-term water projects.

The lifetime of a pump in the pulp and paper industry is relatively short (say five years) before it is replaced or removed from service during plant maintenance or modifications. With such a short lifespan, capital expenditure plays a larger role and LCC modelling is taken less seriously. Several survey participants estimated that less than 10 % of customers in the pulp and paper industry would use LCC modelling.

Even with several reasons to consider LCC analysis and modelling, survey results suggest that customers do not often apply these cost reduction methods. When customers do perform a LCC analysis, the results are thought to have little influence on decision making. In cases where LCC modelling has been used, survey participants state that the model is rarely updated throughout the equipment life cycle.

Survey results revealed that LCC modelling is uncommon in some geographical regions. For instance, a survey participant reports that equipment LCC are not considered in the Mexican engineered solution markets. Similarly, several survey participants mention that LCC modelling is not common practice in China. However the concept of LCC analysis is of growing interest. The exception to this case is foreign companies that are invested in China.

Although end users may take advantage of LCC modelling to minimise their operating expenditure, many survey participants mentioned that EPC companies do not have any interest. This is because operating cost minimisation is outside the scope of an EPC company which is only to plan, purchase, construct, and commission new equipment. All of these tasks are funded by capital expenditure and are outside the value domain of monitoring solutions (Figure 5.8). This conflict of interest between EPC companies and end users poses a significant barrier to market entry.

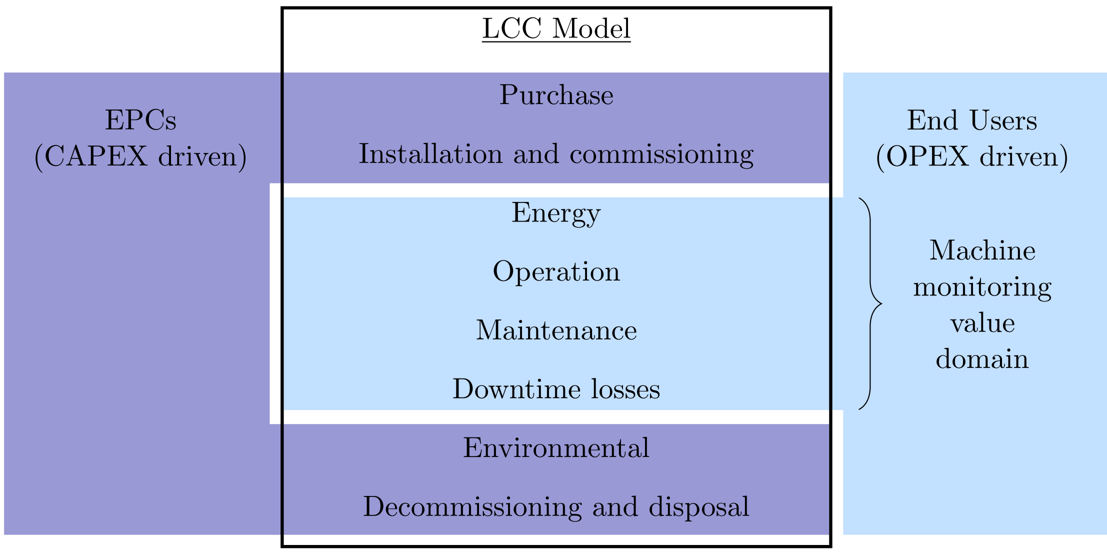


Figure 5.8. Responsibilities and financial focus of EPCs and end users

5.3.3 Customer Machine Monitoring Demand

In this section, the results of survey questions 8, 9, 16, and 17 (see Appendix B) are presented to indicate Sulzer Pumps customer demand in areas where machine monitoring solutions may be applied. Results from survey questions 8 and 9 (Section 5.3.3) evaluate what costs customers are most eager to reduce. Next, Section 5.3.3 shows how often customers discuss machine monitoring solutions for cost saving with Sulzer CSS and sales staff (survey question 16). Finally, results from survey question 17 express what Sulzer CSS and sales staff believe customers currently need most (Section 5.3.3).

Customer Interests

Generally survey results show that any form of optimisation method for cost saving is considered very important for Sulzer Pump customers by CSS and sales staff. However, the importance of three optimisation goals were seen as more important than the others (Figure 5.9). These essential goals are: 1) minimising downtime and loss of production, 2) protecting machinery from major failures, and 3) minimising the energy consumption of equipment. Figure 5.10 shows that this general result varies slightly between business segments.

By assigning a score to each of the response variables in Figure 5.9 (e.g. a 1 representing 'not important' through to a 5 representing 'essential'), a weighted average for each optimisation goal was calculated (Table 5.1). These averages were then used to assign a ranking of relative importance to each optimisation. The three goals mentioned above obtained the highest average scores due to their high number of responses in the 'essential' category. The next highest ranked goals for customers were avoiding unplanned maintenance and maximising pump working life cycle durations. The optimisation goal that was estimated to be least important to Sulzer Pumps customers was minimising the amount of spare parts or consumables used.

Repeating this ranking process for each business segment yielded more industry specific results (Table 5.2). It is clear that equipment functionality is the primary focus in all industries, as protecting machinery from major failures and minimising downtime re-

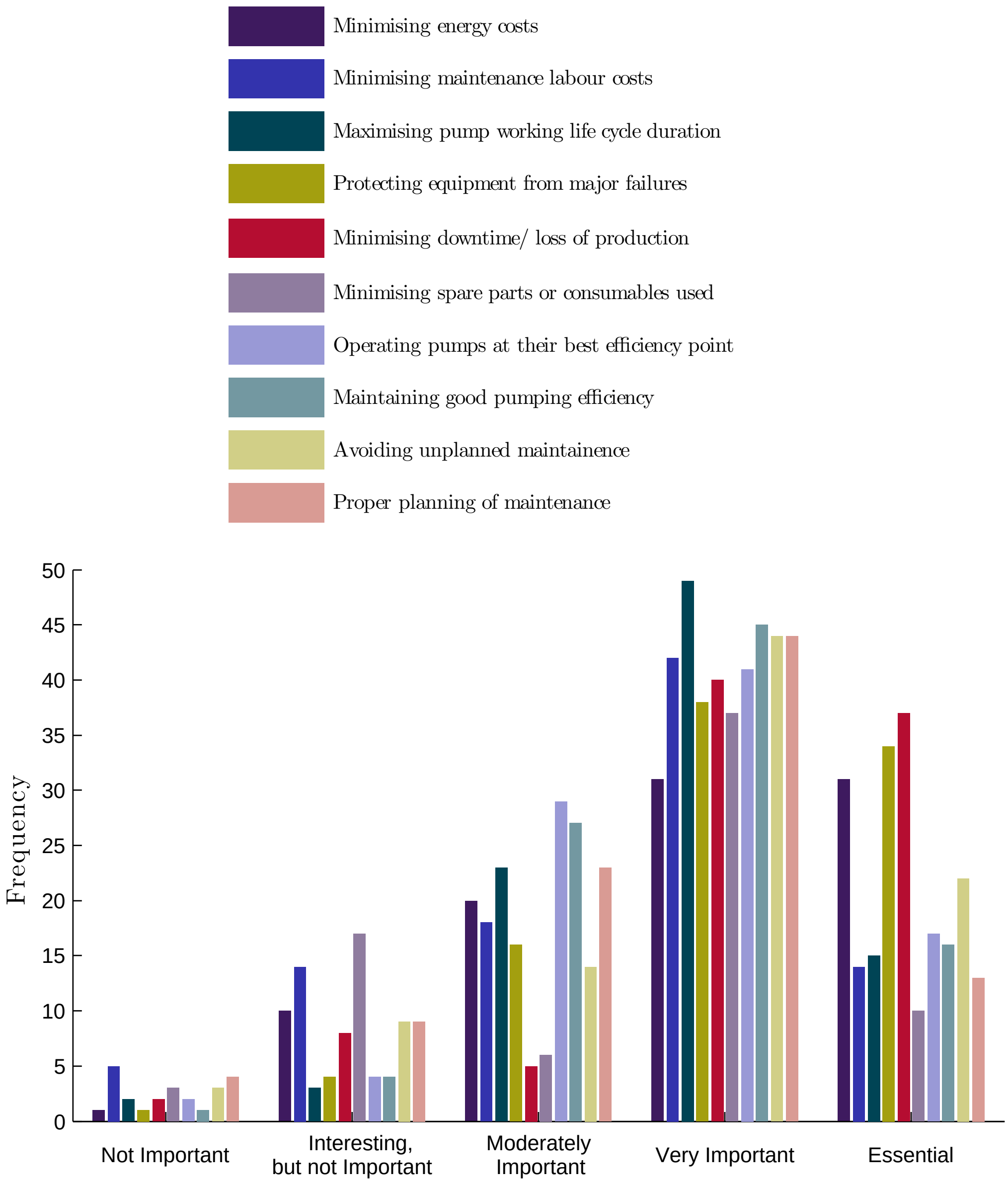


Figure 5.9. The estimated importance of various cost saving methods to Sulzer Pumps customers (all business segments)

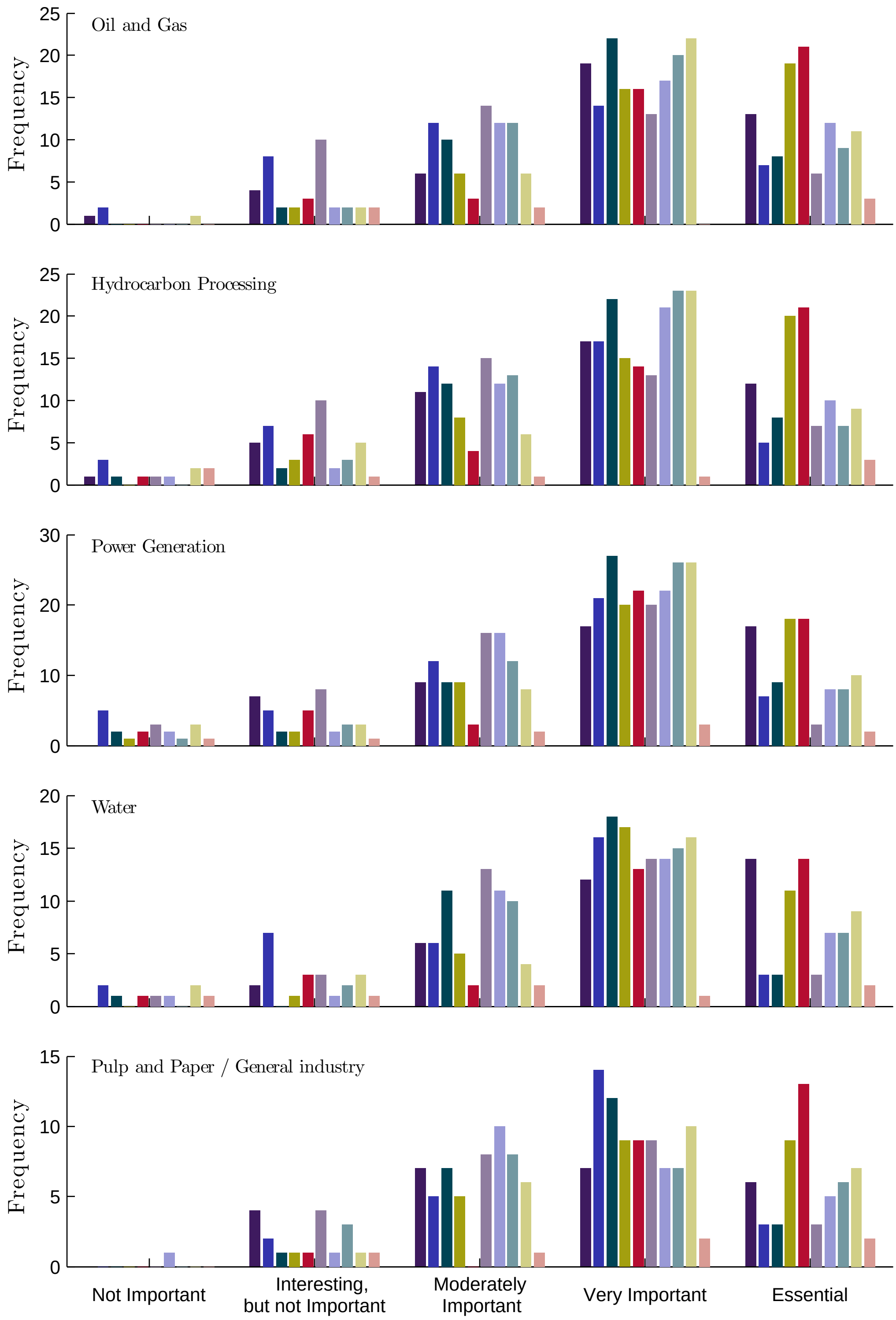


Figure 5.10. The estimated importance of various cost saving methods to Sulzer Pumps customers by business segment. Refer to Figure 5.9 for the plot legend

Table 5.1. Estimate for the relative importance of various LCC saving objectives (all business segments)

	Not important	Interesting, but not important	Moderately important	Very important	Essential	Average Score	Rank
Score	1	2	3	4	5		
Minimising energy costs	1	10	20	31	31	3.87	3
Minimising maintenance labour costs	5	14	18	42	14	3.49	8
Maximising pump working life cycle duration	2	3	23	49	15	3.78	5
Protecting equipment from major failures	1	4	16	38	34	4.08	2
Minimising downtime/ loss of production	2	8	5	40	37	4.11	1
Minimising spare parts or consumables used	3	17	26	37	10	3.37	10
Operating pumps at their best efficiency point	2	4	29	41	17	3.72	7
Maintaining good pumping efficiency	1	4	27	45	16	3.76	6
Avoiding unplanned maintenance	3	9	14	44	22	3.79	4
Proper planning of maintenance	4	9	23	44	13	3.57	9

main the first and second priorities for all business segments. Process scheduling is also clearly important in oil and gas, water, pulp and paper, and general industry, as avoiding unplanned maintenance is their next highest priority. For the business segments of hydrocarbon processing, power generation, and water, process optimisation seems to be their tertiary goal (e.g. efficiency optimisation and energy minimisation).

Considering the top three goals of each business segment, these results suggest that reliability is the primary focus in the oil and gas, pulp and paper and general industry segments. In contrast, results for the water business segment show a bias towards improving energy efficiency. The business segments of hydrocarbon processing and power generation fall in between these two groups, displaying balanced interest for both reliability and energy efficiency.

Table 5.2. Estimated ranked importance of various LCC saving objectives for each business segment

	OG	HPI	PG	W	PPI/ GI
Minimising energy costs	4	5	3	1	8
Minimising maintenance labour costs	8	8	8	7	5
Maximising pump working life cycle duration	5	4	4	5	6
Protecting equipment from major failures	2	1	1	1	2
Minimising downtime/ loss of production	1	2	2	2	1
Minimising spare parts or consumables used	9	7	9	6	10
Operating pumps at their best efficiency point	4	3	6	4	9
Maintaining good pumping efficiency	6	5	5	3	7
Avoiding unplanned maintenance	3	6	5	3	3
Proper planning of maintenance	7	9	7	8	4

More Customer Interests

In addition to rating the importance of the LCC saving objectives shown in Section 5.3.3, survey participants were also asked to suggest other LCC saving methods that they viewed as important to Sulzer Pumps customers. This section provides a summary of these suggestions.

A survey participant working in the engineered solution business segments noted that monitoring equipment log books is essential for tracking of improper maintenance or use of equipment that may lead to suboptimal operation and potentially premature failure. This is a topic that is also of interest to Sulzer for eliminating deputes over equipment misuse as part of warranty claims.

Monitoring equipment from a single location was pointed out as a very important requirement for customers in the power generation industry. This is because power generation plants typically have a central control and monitoring system that integrates all of the plant equipment. Similarly, this requirement is also very important in the hydrocarbon processing industry.

Some pumping applications may impose safety risks to staff working around them. Monitoring and managing these risks was noted as another potential application for monitoring solutions. However, this suggestion was perceived as having a relatively low importance to Sulzer Pumps customers.

A survey participant in configured solutions responded that pump and network monitoring is becoming essential. It has been recognised that simply optimising or monitoring a single system component, i.e. a pump, has significant limitations for system optimisation. Instead, organisations such as the Smarter Water Networks Forum (SWAN) are promoting the importance of taking a systems approach to optimising water distribution networks (Smart Water Networks Forum, 2013).

Customer Focus on Reliability and Energy Efficiency

Figure 5.11 shows the relative focus of different business segments on equipment reliability and energy efficiency. Using a weighting system to calculate an average score for each business segment (on the scale of 1 for 'totally focused on reliability' to 5 for 'totally focused on energy efficiency), the relative focus of each business segment on reliability and energy efficiency were deduced (Table 5.3). These results validate the attractiveness of condition monitoring and energy monitoring to each business segment that were assumed in Section 3.12.

Table 5.3. Estimated relative focus of each business segment on equipment reliability and energy efficiency

	Totally reliability focused				Totally energy focused	Average Score	Reliability focus	Energy focus
Score	1	2	3	4	5			
Oil and gas	9	6	9	12	4	2.90	53 %	48 %
Hydrocarbon processing	7	7	14	11	5	3.00	50 %	50 %
Power generation	5	9	13	14	5	3.11	47 %	53 %
Water	3	2	10	11	6	3.47	38 %	62 %
Pulp and paper/ General industry	4	4	8	5	2	2.87	53 %	47 %

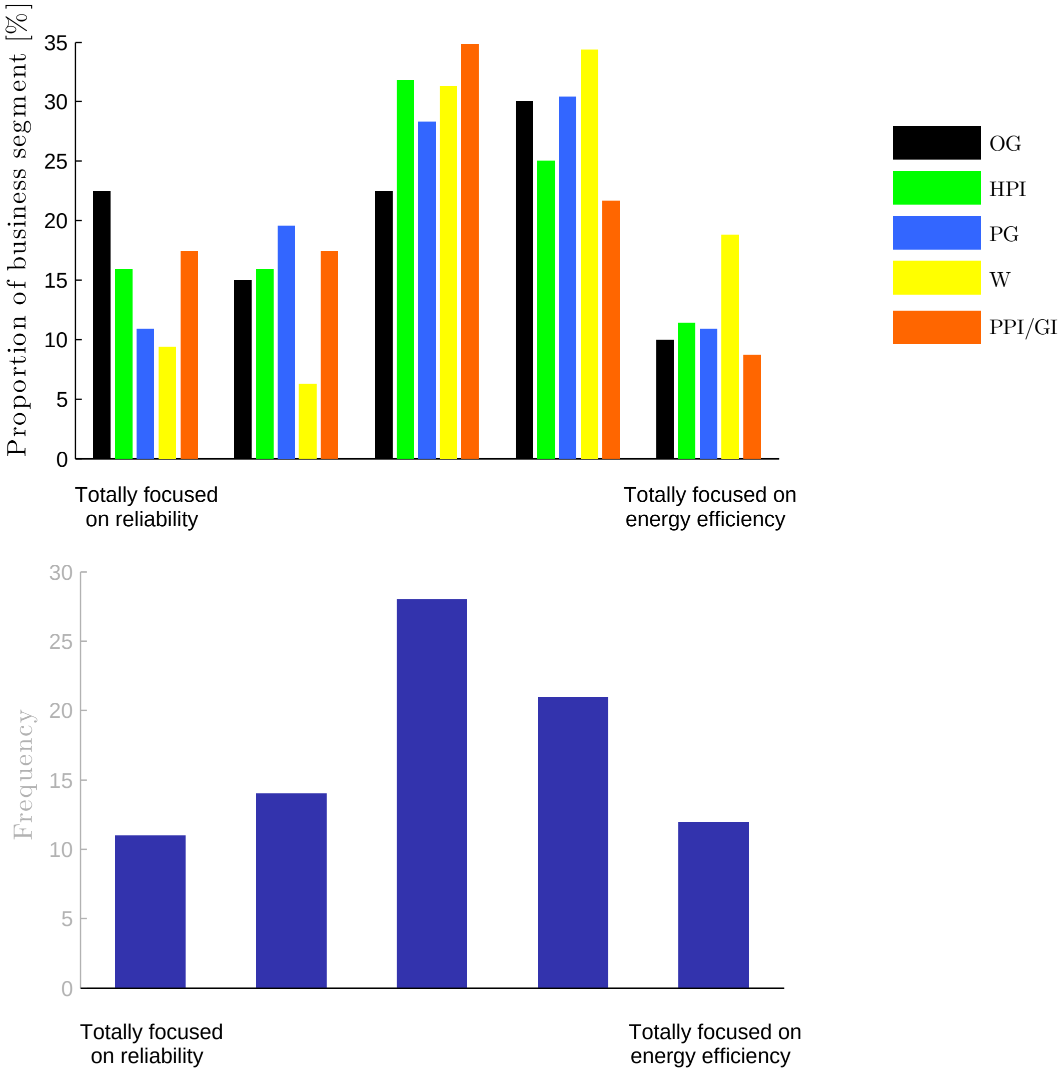


Figure 5.11. The estimated distribution of customer preference for maximising asset reliability or energy efficiency. The upper graph shows the response distribution of each business segment, while the lower graph shows all responses independent of business segment

Similarly to the results shown in Section 5.3.3, the oil and gas, pulp and paper, and general industry segments favour equipment reliability over energy efficiency. This is most likely due to the harsh materials pumped in these industries causing faster pump wear rates, and hence higher maintenance demands. In contrast, pumps in the water and power generation industries mostly transport water which is relatively harmless to pump components. However, water transport is energy intensive, and hence these segments have a bias towards being focused on energy efficient.

Current Customer Contact Frequency with CSS and Sales Staff

Results show that Sulzer has a very low engagement with customers when it comes to machine monitoring solutions with approximately one third of CSS and sales staff that participated in the survey not knowing, or being unable to estimate the frequency at which they discuss machine monitoring with customers. Moreover, of those that did estimate a discussion frequency, approximately 22 % of participants from each business segment stating they never discuss machine monitoring with customers (Figure 5.12). Machine monitoring is sometimes discussed during the pre-purchase stages of projects. However, several participants noted that machine monitoring is rarely discussed with EPC companies who typically limit their supply requests to monitoring sensors.

Only 20 % of participants that estimated a discussion frequency mentioned that they discuss machine monitoring solutions with customers regularly, i.e. on a weekly basis or every customer visit. The majority of survey participants who estimated a discussion frequency (58 %) indicated that they only discussed machine monitoring solutions with customers on a monthly basis or less. Several participants in this group mentioned that machine monitoring was only discussed if the subject was brought up by the customer.

What Sulzer Pumps Customers Need (from the viewpoint of Sulzer CSS and Sales Staff)

CSS and sales staff were asked to suggest services that they thought were most beneficial to Sulzer Pumps customers. Approximately one third of responses to this question commented on service aspects that were not related to machine monitoring. Some survey participants expressed that there is little difference between many pump products on the market today and that the quality of service from pump suppliers (both presales and after sales) was a key factor in customer decisions. Several indicators of good service were noted as:

- Proper pump selection guidance

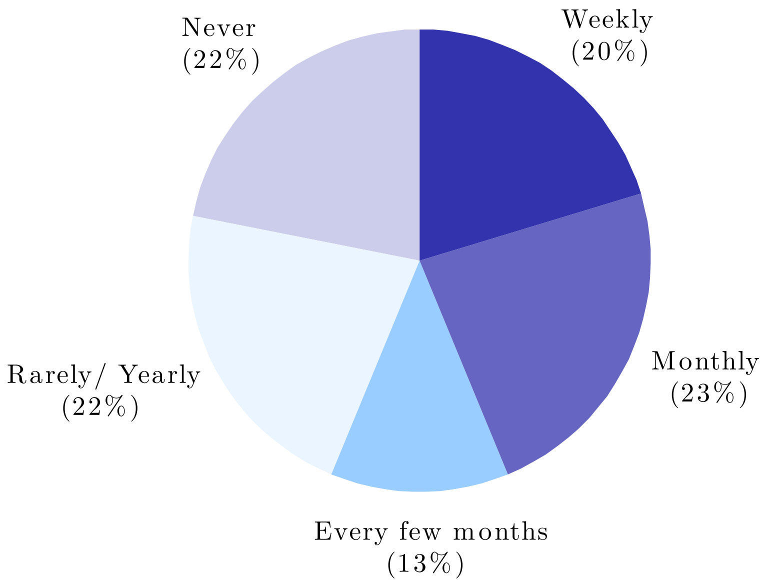


Figure 5.12. Frequencies at which Sulzer CSS and sales staff discuss machine monitoring solutions with customers (all business segments)

- More dedicated service and spares support
- Faster service turnaround times
- On time delivery (both new equipment and spare parts)
- Instant parts quotes
- Yearly maintenance contracts

In terms of machine monitoring solutions, some survey participants suggested that Sulzer needs a standard offering, i.e. a standard means to acquire and analyse data from Sulzer pumps. This is important, as it will allow Sulzer customer support services to better diagnose pump issues. A survey participant mentioned that currently they feel that some competing pump or machine monitoring solution suppliers have more knowledge on Sulzer Pumps than Sulzer does simply because they have more experience monitoring Sulzer equipment. This situation could be very detrimental to Sulzer Pumps service reputation, and hence Sulzer has a strong motivation to become more active in the field of machine monitoring.

Several survey participants suggested that customers would value condition monitoring solutions in order to improve equipment reliability. The solution should be cost-effective and ideally contain predictive maintenance features. Furthermore, it should be designed to minimise the number of maintenance staff required. Pump performance tests were also suggested as a valuable method for ensuring reliability.

Energy saving services was a popular suggestion. Responses suggested that energy audits or site surveys for increasing the energy efficiency of pumps and pump systems were in demand. For large pumps, condition assessments and efficiency checks may save customers significant energy costs. For all pumps systems, network optimisation and control services may also offer significant cost savings to customers.

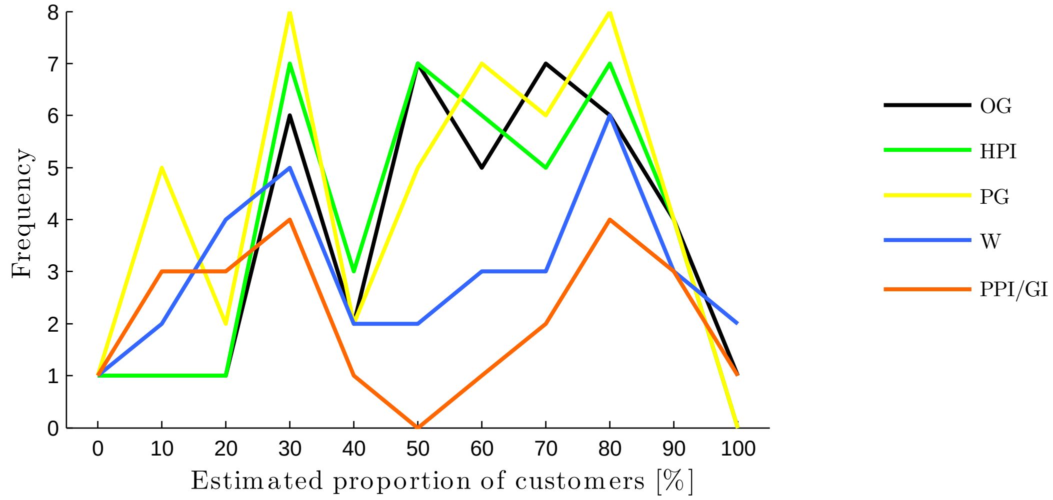
Other suggestion included: control room based machine monitoring systems, spare parts inventory management, contract maintenance programs, and preventative maintenance programs. Whatever the solution, it was suggested that a process or service ensuring customers may switch machine monitoring providers will be important for capturing market share.

5.3.4 Customer Current Machine Monitoring Solution Usage

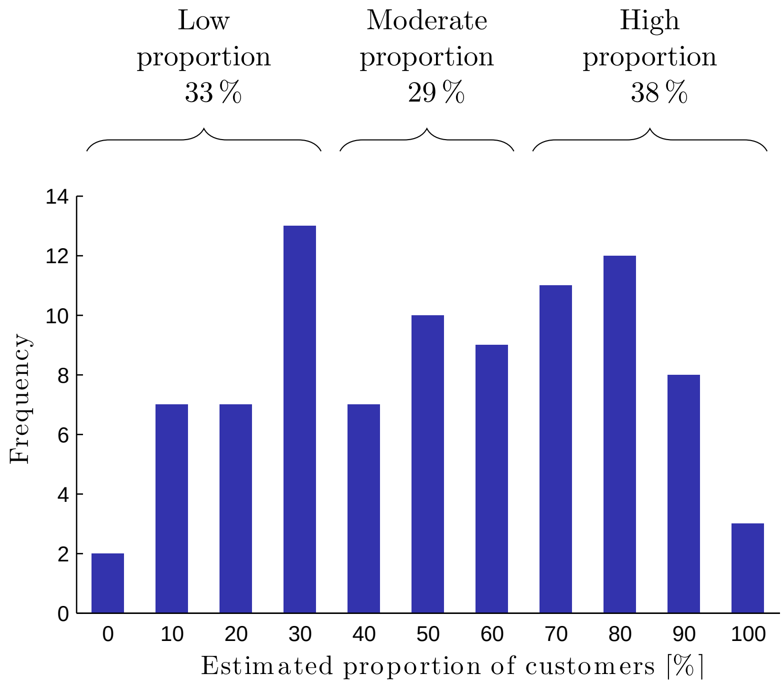
Figure 5.13 shows estimates for the proportion of Sulzer Pumps customers that already use machine monitoring equipment or services. As shown in this figure, the estimates provided by survey participant had a wide variation and did not have a clear single peak value. There was also no apparent dependency of these distributions on business area. However, there is a clear difference between the distribution of engineered solutions and configured solutions.

The distributions in Figure 5.13 show that several survey participants believe that either 30 % or 80 % of Sulzer Pumps customers (independent of business segment) currently use machine monitoring equipment or services. Between these two peaks engineered solutions maintains a relatively flat distribution. Averaging estimates from participants in engineering solutions yields that approximately 55 % of Sulzer Pumps customers already use machine monitoring solutions in these business segments.

In contrast to engineered solutions, the distribution of estimates from configured solu-



(a) Survey response distribution of each business segment



(b) Survey response distribution independent of business segment

Figure 5.13. The estimated proportion of Sulzer Pumps customers that already use monitoring equipment or services

tions has a local minimum between the distribution peaks at 30 % and 80 %. Unfortunately, the reason for this double peak in the distribution of consumer machine monitoring usage estimates in the water segment (Figure 5.13a) is unknown. Survey responses showed no correlation with business area. However, approximately 20 % more participants estimated that more than 50 % of customers already used machine monitoring solutions, making the distribution peak at 80 % larger than that at 30 %.

The number of participants working in the pulp in paper business segment that estimated more than 50 % of customers use machine monitoring, was approximately the same as the number of participants that estimated less than 50 % of customers use machine monitoring. Hence the average estimated proportion of customers using machine monitoring in pulp and paper was approximately 50 %. However, the average estimate of the four participants working purely in the pulp and paper industry (Figure 5.3) was 20 %. Taking this into account, it is assumed that the proportion of customers currently using machine monitoring solutions in the pulp and paper industry is approximately 20 % - 30 % and the secondary peak in the distribution, shown in Figure 5.13a, is due to cross-correlation with estimates made by participants also working in other business segments.

5.3.5 Preferred Machine Monitoring Solutions of Sulzer Pumps Customers

In this section, survey results indicating current preferred machine monitoring solutions of Sulzer Pumps customers are presented. Firstly, Section 5.3.5 overviews which machine monitoring methods are currently preferred. Secondly, the popularity of various technologies used for machine monitoring is shown in Section 5.3.5. Finally, Section 5.3.5 summaries the popularity of various competitor machine monitoring suppliers.

Preferred Machine Monitoring Methods

Figure 5.14 shows an estimated overview of how popular various machine monitoring methods are with Sulzer Pump customers. It is not surprising that automated machine protection is a popular method for cost saving since protecting equipment from major failures was identified as an important goal of Sulzer Pumps customers in Section 5.3.3. This type of condition monitoring is most popular within the engineered solution segments since it improves the integrity of their high value equipment. Automated protection is also popular in the water segment since it reduces ongoing labour costs and avoids major failures, which are very important objectives to most municipalities. Additionally, automated protection is desirable for application demanding remote or centralised monitoring. Although advanced machine protection can be expensive, automated protection can also be a cost effective method of condition monitoring and is used to some degree in all business segments.

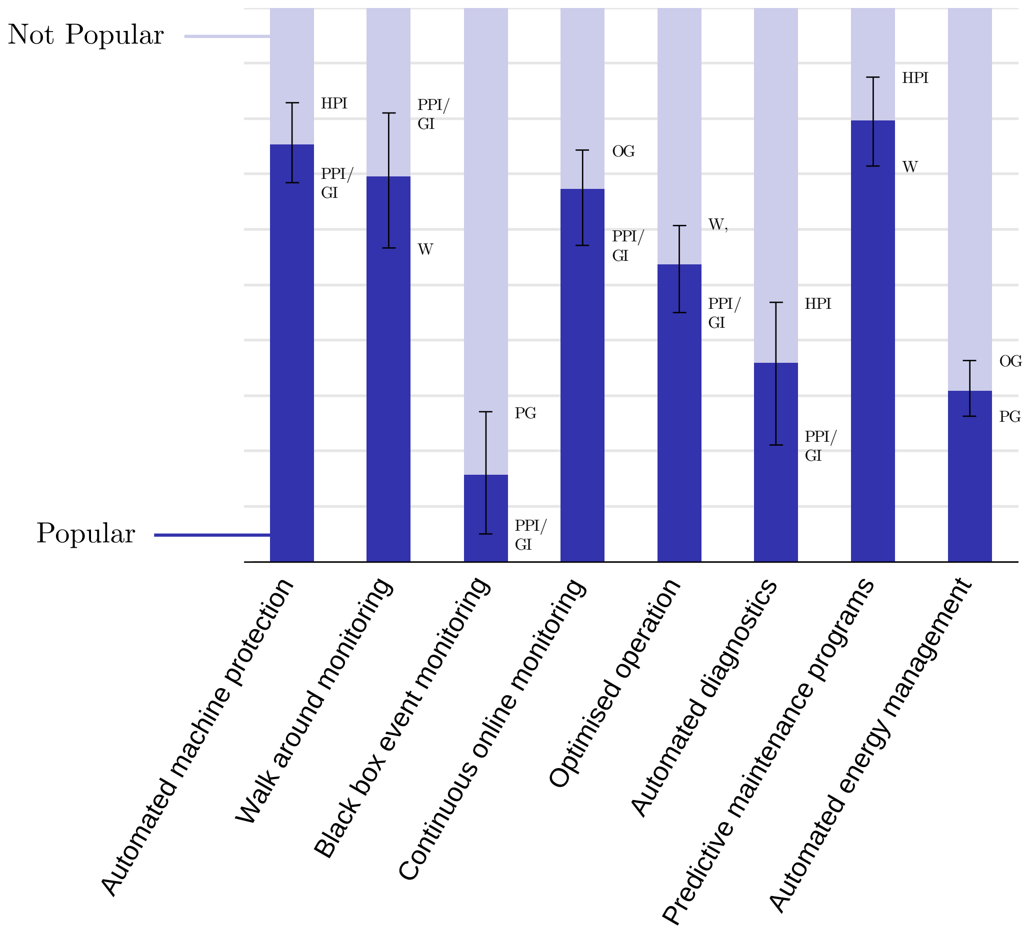


Figure 5.14. Estimated popularity of various machine monitoring methods with Sulzer Pumps customers. Error bars represent the variation of results with business segments. Business segments with the estimated highest and lowest popularity are indicated

When automated protection is not a viable solution, walk-around monitoring solutions are often used instead. Results indicate that the most common reason for walk-around monitoring is the high cost of automated or permanent monitoring equipment. For example, walk-around solutions are popular in the pulp and paper industry where budgets for machine monitoring are reported to be rather tight. Other reasons customers chose to use walk-around monitoring equipment are to verify automated monitoring systems are functioning correctly, their relative simplicity, and for irregular monitoring activities, i.e. troubleshooting. Disadvantages of walk-around equipment is their low precision compared to permanently installed equipment, their high labour intensiveness, higher risks of human error, and the practicalities of repeated measurements. All of these reasons make walk-around solutions an unpopular solution in the water segment where large distribution networks require monitoring. In the engineered solution segments walk-around solutions are used for monitoring smaller and less critical assets.

Survey participants had a low awareness of black box machine monitoring, and hence this method has a very low popularity. Moreover, few survey participants could comment on its popularity. Those participants that could comment noted that customers appreciated the low cost and simplicity of the technology. However, the reactive nature of the technology limits its popularity for cost saving applications. One participant from the ASP business area mentioned that the EPC and project management company, Bechtel now includes black box monitoring equipment in every project. This is most likely done for minimising warranty disputes with clients. It was also suggested that black box monitoring increases awareness among personal involved with machinery which may result in less failures due to misuse.

Continuous online monitoring is popular with the engineered solution business segments for application on high energy pump for similar reasons as automated protection. It is often implemented in conjunction with centralised control through SCADA or DCS systems. The popularity of continuously online monitoring is growing in most business segments to increase proactive decision making in maintenance programs.

Survey results contained mixed feedback on the popularity of methods aimed at achieving optimised operation. Generally, customers would like to increase process efficiencies to save cost, but this is not as essential as reliable operation of equipment in most business segments. The water and power generation business segments have the most interest in optimising their processes since energy costs make up a large portion of their total LCC.

Automated diagnostic systems are desired by customers since they can reduce their dependence on experienced maintenance staff. However, condition monitoring solutions containing such functionality are typically expensive and so are only applied to critical equipment. The cost of these solutions also limits their popularity with customers. Several survey participants also believe that these advanced systems are not fully utilised by customers due to their complexity.

Predictive maintenance or automated prognosis is significantly more advanced and costly than automated diagnosis. Moreover, a good understanding of automated diagnostics is necessary to develop predictive maintenance technology. However, survey results show that the popularity of predictive maintenance far exceeds that of automated diagnostics. This counter intuitive result, combined with written survey responses that showed little evidence of customers having functioning predictive maintenance technology, most likely represents the popularity of predictive maintenance concepts rather than the popularity of actual predictive maintenance solutions. Although technology in this area is still immature, survey results indicated that some customers may use relatively simplistic predictive maintenance programs (such as combining spare part usage predictions with spare part inventory management) to minimise downtime.

Similar to automated diagnostics, automated energy management is relatively unpopular with customers. Survey participants recognised energy management as an important issue with a growing importance and a large market potential. However, like other automated solutions the cost of technology in this still deters customers from adopting energy management schemes.

Preferred Machine Monitoring Technologies

Survey results indicate that temperature and vibration measurement technologies are by far the most popular fault detection methods of Sulzer Pumps customers. These technologies were mentioned in the survey results as preferred by customers approximately ten times more than any other technology. This is because they are cheap, well known, and well understood technologies that measure quantities that may be correlated to the condition of machinery.

Monitoring of mechanical seals remains a point of interest in most business segments. However, due to seal monitoring technology being rather immature, customers are interested in leak detection as the next best solution. Interest in oil analysis appears to be uncommon, which may be due to the technology immaturity, or its limited applications compared to vibration and temperature measurement technologies.

Preferred data sampling frequency (e.g. permanent online, handheld, etc) is dictated by the budget of the customer. Although online and automated monitoring is desired by many customers for its continuous operation and its fast reaction to faults, customers with tight budgets will still opt for cheaper offline solutions. Results indicate that this is often the case for customers in the water and pulp and paper industries.

Some survey responses from the engineered solution business segments emphasised that it is important for monitoring equipment to fully integrate with existing plant equipment, including DCS and SCADA systems. It is a common opinion that many customers in the hydrocarbon processing, power generation, and water industries will not be interested in any solutions that can not fulfil this requirement. Survey results also pointed out the importance of the Bently Nevada brand name, and indicated that some clients are unlikely to use competing solutions due to their established familiarity with the Bently Nevada products.

Preferred Machine Monitoring Equipment and Services Providers

Survey results confirm that Bently Nevada is the most common machine monitoring solution provider amongst Sulzer Pumps customers. They have a well established reputation for their machine protection solutions and are often recommended by consultants. This has lead to Bently Nevada products and services becoming a seemingly unofficial industry standard in some markets. Several participants also mentioned that Bently Nevada's global technical support service has also contributed to their success.

Besides Bently Nevada, other major companies supplying machine monitoring solutions to the oil and gas and hydrocarbon processing industry are ITT, SKF and Rockwell Automation. SPM was also noted as popular in the ASP business areas for their availability and local support. A participant from the oil and gas segment noted that although these large companies are the major equipment suppliers, the important market players are the sub-contracting condition monitoring service companies that use the equipment to monitor equipment across entire facilities.

In the power generation industry, Solar Turbines are known to provide turbine monitoring services with turbine refurbishment services as a complementing business. In addition to Bently Nevada, other major providers of monitoring equipment for power generation application are known to come from Siemens, ABB and Schneider Electric. In the water industry, monitoring products from ITT and Metrix were reported as popular, equipment from ITT and Patorol were mentioned as popular in the pulp and paper industry. Other providers mentioned in the survey results included IRD Mechanalysis and John Crane.

5.3.6 Current Customer Machine Monitoring Solution Satisfaction

Approximately half of the survey participants either could not comment on whether Sulzer Pumps customers were satisfied with their currently machine monitoring solutions. Of those that did comment, 55 % believed that customers were satisfied with their current solutions while only 22 % thought that customer were not (Figure 5.15). The remaining responses were neutral, or indicated that customer were only partially satisfied with their current solutions.

Reponses indicating that customers were not satisfied or only partially satisfied with their current machine monitoring solutions did not correlate with any particular business segment. Most neutral responses expressed that although customers were satisfied with their current solutions, they were always going to looking for better and cheaper solutions. This represents the nature of companies, which is to continually better their current profitability. Hence there will always be space in the market for better 'value' solutions.

Results indicated that although customers in the water segment are less than satisfied with their current solutions, their tight budgets will often prevent them from changing solution. Similarly, often customers in the pulp and paper industry are satisfied with handheld solutions only due to the cost of online solutions. A participant working in both

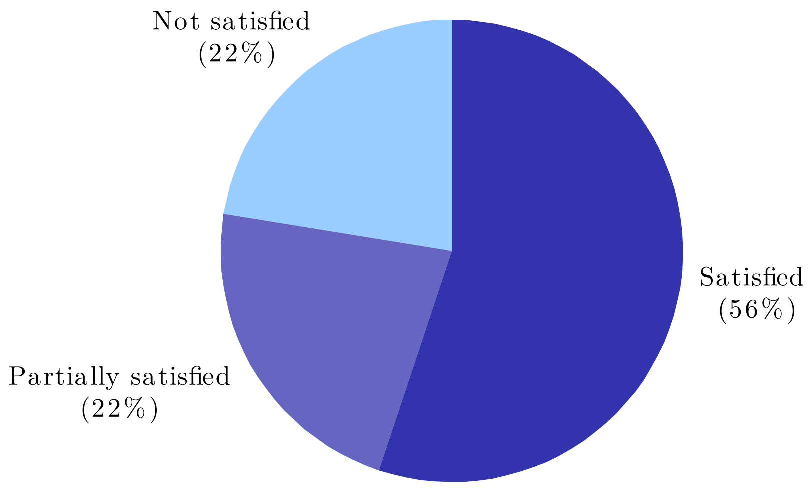


Figure 5.15. Estimated satisfaction of Sulzer Pumps customers with their currently machine monitoring solutions

of these business segments estimated that only 50 % - 60 % of customers are satisfied with their current analysis methods.

The complexity of some solutions can also be a cause of customer dissatisfaction. For example, some participants believe that the complexity of machine monitoring solutions in the engineered solution business segments is too high since some users struggle to understand the monitoring equipment or the data it produces. Another survey response from these business segments noted that in some situations, customers may be satisfied with machine monitoring equipment but not with the service from their providers (using Bently Nevada as an example provider).

5.3.7 Customer Evaluation of Return on Investment

The vast majority of survey participants (71 %) did not know if customers assess the return on machine monitoring investments or could not comment on the topic (Figure 5.16). Some survey participants believed that after sales support in aiding customers to evaluate their ROI was outside of the current Sulzer Pumps supply scope. Few participants that stated customers do not calculate their return on machine monitoring investments provided explanation as to why. It was suggested that machine monitoring investments are only justified by rational, rather than financial figures.

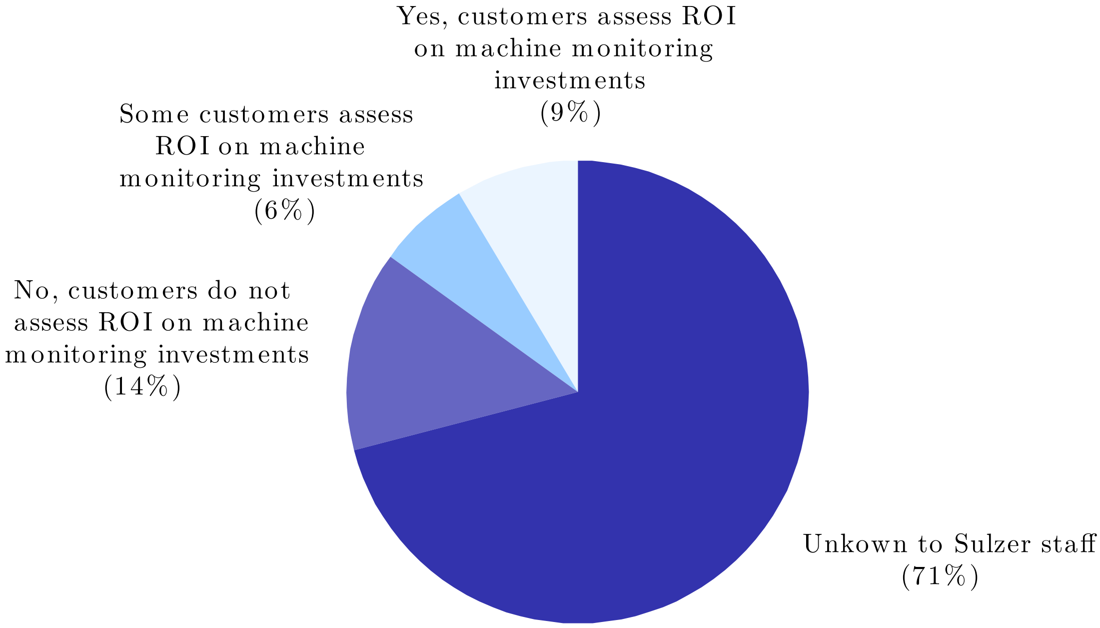


Figure 5.16. The proportion of Sulzer Pumps CSS and sales staff who believe customers assess their return on machine monitoring investments

Responses indicating that only some customers assess their return on monitoring investments also communicated that few customers know how to do so, or may only be able to evaluate ROI in non-financial terms. Participants that indicated customers do assess their return on investment (9 %) believed that this was a critical task for optimising maintenance programs. However, no participant knew how Sulzer Pumps customers perform their ROI calculations. Assessing ROI was expected to be more common in large facilities with high value equipment. In these cases condition monitoring equipment may form 5 % - 10 % of the equipment value and hence is a substantial investment to track.

5.3.8 General Comments on Survey Responses

Overall, survey participation was good. However, the proportion of participants that completed the survey beyond the 'participant information' questions was relatively poor (only about 66 %). Furthermore, the number of participants that completed the survey who either did not comment on their choices, or indicated that they did not have any opinion on key topics brings into question the Sulzer Pumps engagement with its customers. For example, when asked to comment of Sulzer Pumps current satisfaction with their current machine monitoring solutions (customer demand survey question 13, see Appendix B), responses such as those listed in Figure 5.17 arguable suggest that Sulzer Pumps does not take a proactive approach to ensuring customers needs are fulfilled.

In your opinion, do you think our customers are satisfied with their current condition monitoring data analysis and interpretation solutions?

I believe so - they haven't asked to explore other options.

Sorry. I don't know.

I've never heard evidence of unhappiness.

I don't know.

I am not sure.

Consult with CSS.

(I have) no contact with operator once new equipment sold.

Customers do not generally bring this up as a part of our scope of supply.

Figure 5.17. Examples of survey responses indicating a possible lack of engagement of Sulzer Pumps with its customers

5.4 Summary

A survey designed to assess the demand for machine monitoring solutions amongst Sulzer Pumps customers was presented and distributed to Sulzer staff in regular contact with Sulzer customers. Previous similar internal surveys have been distributed to only

Sulzer CSS staff. However, significantly more survey responses to the current survey were achieved by also inviting Sulzer sales staff to participate. Approximately two sales staff participated in the survey for every CSS participant.

Survey results showed that application of LCC modelling is dependent on customer segments. End users and operators may appreciate the concept, but few actually use LCC analysis or modelling methods. Customers that do use LCC analysis are often not open to share data or analysis methods, particularly those in the oil and gas segment. EPC customers and other consultant rarely use LCC modelling as the results do not generally optimise their business. Overall, application of LCC analysis and modelling in industry appears to be weak.

The primary goal of most customers was to avoid equipment downtime. Secondary and tertiary goals were avoiding major equipment failures, avoiding unplanned maintenance, saving energy costs, or process optimisation depending on business segment. The oil and gas, hydrocarbon processing, pulp and paper, and general industry business segments tended to be slightly more focused on reliability goals, while the power generation and water business segments tended towards achieving efficient operations.

The frequency at which Sulzer staff discuss machine monitoring solutions was considered low with only 20 % of Sulzer sales and CSS staff indicating they discuss the topic on a weekly basis. Current machine monitoring usage appears to be higher in the engineered solution business segments. However, no particular business segment or area seemed to have exceptionally high or low usage relative to the other business segments.

Currently automated monitoring solutions are desired by customers to save on labour costs. However, the cost of these solutions deters customers for using them and results in less expensive walk-around monitoring solutions remaining popular. Interest in advanced monitoring solutions such as predictive maintenance is high, but usage and knowledge of these methods appears to be low. Awareness of black box monitoring technology also appears to be low, and so results deemed the solution unpopular.

Overall the results of this survey gave an adequate overview of the machine monitoring demand of Sulzer Pumps customers. However, it was apparent in the survey responses that Sulzer Pumps has a low engagement with its customers in this market. For a more in depth review of customer demand it was recommended that a focus market be selected to narrow the scope of the customer development process.

Chapter 6

Selecting Focus Market Segments

6.1 Introduction

In Chapter 3 the activities of condition monitoring and energy monitoring were introduced, and Sulzer's experience in each was noted. In Chapter 5 an assessment of the present customer demand for machine monitoring was shown as an indication of the present business environment market forces. In this chapter, other machine monitoring business environment factors such as industry trends and economic factors are identified and used to evaluate the most attractive machine monitoring markets for Sulzer Pumps.

6.1.1 Objective

The objective of the work presented in this chapter was to identify the business model environment (see Section 4.3) within each of Sulzer Pump's focus markets in order to determine the attractiveness of each market segment. This allowed the most attractive market segment with the most favourable business model environment to be identified.

6.1.2 Method

To decide on a focus industry segment for the current study, preliminary research was done to obtain an overview of market requirements and Sulzer's current expertise in each industry. This information was gathered through several sources. Firstly, internet and intranet sources such as Sulzer internal and public reports, news articles, industry magazines, government reports, academic papers and market analysis reports were reviewed. Secondly, the opinions of several Sulzer staff members on the present market requirements for machine monitoring were collected through personal correspondence. Staff members in the areas of business development, product development, customer support services, business intelligence and sales were contacted to contribute their experience. The results of this research are presented in Sections 6.2 to 6.6.

To evaluate the appeal of each Sulzer focus markets, the Baaken's market framework (Spohn, 2004) was used (see Section 6.10). This approach is similar to the product portfolio concept of Boston Consulting Group (Henderson, 1970), but instead uses indexes indicating market attractiveness to Sulzer, and Sulzer's competitive position, rather than indexes of market growth and market share. The criteria for evaluating these two indexes are presented in Section 6.7 and Section 6.8 respectively. To gain an overall perspective of which markets are most attractive, these two indexes may be plotted against one another as shown in Figure 6.1. Attractive markets where Sulzer has a strong competitive position have the greatest potential for successful business ventures. These markets are located in the top right hand corner of this plot ('+' area in Figure 6.1).

6.1.3 Estimating Market Size

In the following business segment analyses, market size estimates are shown to indicate the potential of each segment. Estimates from both 'inside-out' 'outside-in' perspectives are shown. Inside-out estimates were made with sales data provided by Sulzer business development or sales staff. Outside-in estimates presented are sourced from market analysis reports such as those from Frost and Sullivan.

Frost and Sullivan consultants have been following the condition monitoring market since the 1980s. They provide several reports that estimate the size of various condition monitoring market subsets and provide outlook on market trend. The most recent reports analysing the condition monitoring market are:

1. Frost and Sullivan (2011): World condition monitoring equipment market
2. Frost and Sullivan (2012): Global condition monitoring services market

3. Global Industry Analysts Inc. (2011): Machine condition monitoring market

However, these specialist reports are expensive to purchase with typical prices between \$4000 and \$6000 US Dollars.

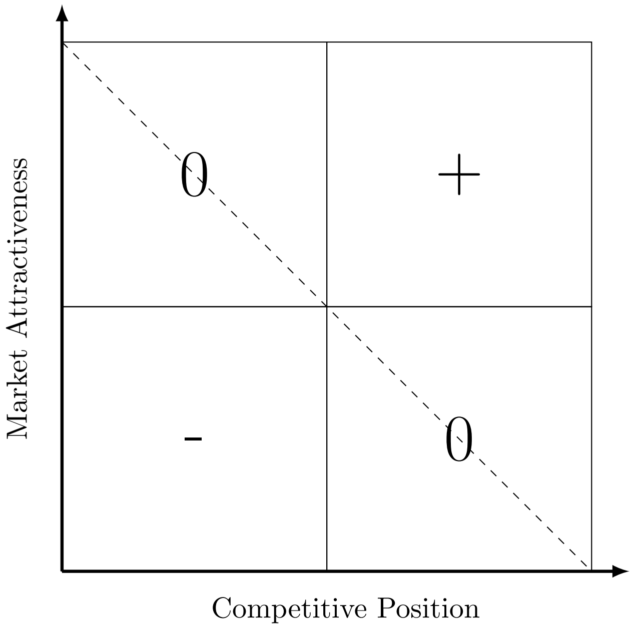


Figure 6.1. Portfolio matrix of Baaken showing potential for business success

6.2 Oil and Gas

Within the oil and gas industry there are three major segments: production, transformation, and transportation (Figure 6.2). The production segment (also referred to as upstream) includes oil and gas extraction and processing either onshore or offshore. The transformation (downstream) segment includes refining oil and liquefaction or regasification of gas products. For Sulzer this is the hydrocarbon processing industry (see Section 6.3). The transportation (midstream) segment includes transporting oil and gas produce either via tanker vehicles or by pipelines. For Sulzer this is the pipeline industry.

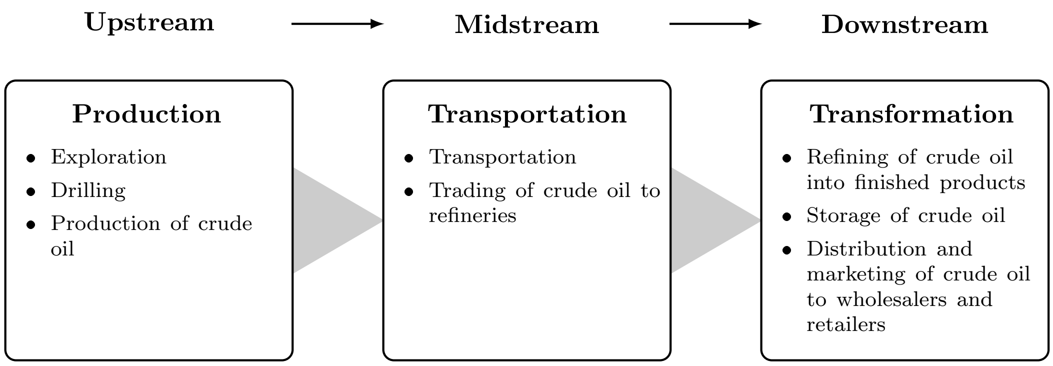


Figure 6.2. Activities in the three segments of the oil and gas industry (*Source: PennEnergy Research (2013)*)

6.2.1 Production

Malcolm Watson (Sulzer Pumps UK employee) works with Sulzer customers in the oil and gas production industry based in the North Sea. He believes that entry into the condition monitoring market for oil and gas production equipment will be difficult for several reasons. Firstly, Sulzer has very limited experience in condition monitoring of oil and gas production equipment, and does not currently offer condition monitoring products or services to customers in the oil and gas industry. Tony Brennan (Control and Instrumentation Manager, Sulzer Pumps UK) states that although Sulzer Pumps provides instrumentation on the majority of engineered pumps, condition monitoring equipment is only provided when it is requested by the customer.

Secondly, this market has well established competitors who hold large maintenance contracts with customers, namely SKF and XPD8 in the North Sea area. Moreover, large customers such as BP have indicated that they have no intention to change maintenance contractors any time soon. It is also well known that GE has a large market share (approximately 80 % (Nyitray, 2013)) of the global condition monitoring and machine protection equipment market for the oil and gas industry.

Thirdly, many oil and gas production customer already have condition monitoring equipment installed. However, it is often not utilised. When under pressure to produce prescribed quotas, warnings from existing condition monitoring equipment are often ignored to ensure quotas are met. Hence, attempting to sell condition monitoring products or services to customers in the oil and gas industry that do not fully utilise their current equipment will be difficult.

Fourthly, the oil and gas industry has stringent reliability and safety standards, such as ATEX certification as mentioned in Section 3.5.2. These standards require equipment used in the oil and gas industry for particular tasks to meet certain requirements. Costs incurred creating products which conform to these requirements often makes these products too expensive to sell in other markets, hence limiting product diversity.

As an alternative to traditional condition monitoring and machine protection, Malcolm suggests that other services such as 'in-line performance testing' could better meet the present industry demands. This kind of service would involve testing the performance of installed pumps and evaluating if they are the best suited equipment for the task. This is currently of interest due to changing productions rates and the need to re-rating current systems. The objective of providing such a service would be to gain business through retrofit and re-rate projects.

Recently, Sulzer Pumps signed a long-term contract to collaborate with FMC Technologies in supplying subsea pumps to the oil and gas exploration and production industries (Sulzer Ltd, 2013g). Due to the nature of subsea mining, reliable remote control and monitoring systems are essential. Hence, this agreement leveraging Sulzer Pumps business in the subsea market could also promote machine monitoring developments at Sulzer Pumps.

6.2.2 Pipeline

The pipeline industry consumes the least energy of these three oil and gas subsegments. However, energy costs account for 60 % - 80 % of pipeline operating costs (Sulzer, 2012). For companies that have upstream or downstream business, the energy cost of their pipeline operations are relatively small in comparison and so are neglected. For such companies condition monitoring and reliability are considered most important.

6.2.3 Market Size Estimate

Rich Niiranen, head of Sulzer's oil and gas business segment, stated that the present global market size for engineered pumps in the upstream oil and gas industry is approximately 5 billion US dollars (3.8b EUR). He expects the condition monitoring subsegment to only be a small portion of this, i.e. 1 %~3 % or 50m~150m US dollars.

Figure 6.3 shows historical and forecasted Sulzer order intakes for new equipment in the oil and gas subsegments. Notice that new equipment orders can vary substantially with time. However, the new equipment market for the production subsegments is typically greater than that of the pipeline subsegment. Again assuming that the order intake for condition monitoring equipment and services would be a small proportion of these values (i.e. 1 %~3 %), then the present potential market size for the condition monitoring subsegment would be approximately 3.7m~11m US dollars for the upstream and pipeline industries.

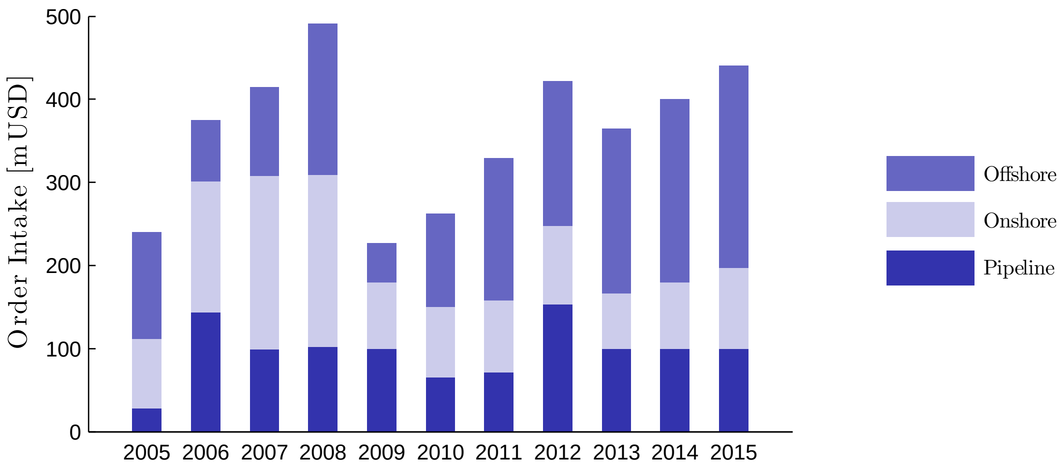


Figure 6.3. Past and budgeted new equipment order intake for oil and gas subsegments (*Source: Rich Niiranen*)

In a recent interview with Chevron (Sulzer, 2012), Sabine Sulzer was told that a Sulzer machine protection system supplied for Sulzer pump and motor packages (of \$400,000~\$500,000 value) would not be of interest to Chevron for a price of \$100,000. Their reasons were that they would have to retrain their staff to operate the new systems, and that they did not need advanced machine protection for onshore applications where many personal are available for troubleshooting.

6.3 Hydrocarbon Processing

Of the three oil and gas subsegments introduced in Section 6.2, the transformation segment is by far the most energy intensive accounting for about half of the total energy consumed by the total oil and gas industry (International Petroleum Industry Environmental Conservation Association, 2007). Moreover, as the oil and gas production subsegment relies more on oil fields that are difficult to access, crude oil quality degrades and requires more energy to refine. Hence efficiency and reliability are very important.

Sulzer's present head of hydrocarbon processing business segment, Mick Wigglesworth, suggests that condition monitoring opportunities in the hydrocarbon processing industry will be low after consulting with his colleagues. The reason for this is that most hydrocarbon processing plants already have centralised control and monitoring systems due to the nature of their operations (i.e. refining materials to specified grade). Furthermore, stringent environmental and health and safety regulations enforced in this industry favour established products.

Spyros Rotsos, sales manger for South Eastern Europe, expressed that the overall feeling of salesmen in his area was that intelligent pump systems with predictive maintenance were not a high priority in the market at present. He mentions that this is especially true for EPC customers and customers in the hydrocarbon processing industry. He concludes that the power generation market may be better suited as an entry market at present.

Industry news also suggests that the current market conditions are not favourable with few refineries investing to improve profitability. This is thought to be due to shortages of cash after many refineries suffered heavy losses in profitability during the 2010 recession (BP plc, 2011). The recent closure of approximately 10 % of European refineries is also thought to be a repercussion of the same economic downturn (Rozhnov, 2013).

In addition to reduced plant numbers, the average European plant utilisation has declined from approximately 90 % in 2005 to 75 % in 2012 (Watkins, 2012) adding to losses in profitability. One reason for this low utilisation is that the balance of plants capable of producing gasoline and diesel fuel does not match the current market demands. This is because many European refineries (> 50 % (Rozhnov, 2013)) were built after World War II and were designed for gasoline production. In fact, up until the 1990s gasoline production was twice as high as diesel production, whereas now diesel production exceeds gasoline production by a factor of three. Moreover, the gasoline-to-diesel production ratio is expected to reach 1:4 by 2020 (European Petroleum Industry Association, 2013).

In contrast, the hydrocarbon processing industry in India has experienced high growth recently with refining capacity increasing by 15 % in 2012. Another 10 % of refining capacity is expected to be added in 2013 (Khan, 2012). Mick Wigglesworth states that Sulzer Pumps intends to increase its presence in India to support local production. However, he believes that the main customer need in India is high quality pumps (Kirstein, 2013), rather than improved machine monitoring.

6.3.1 Market Size Estimate

As mentioned in the previous section, most hydrocarbon processing plants tend to have condition monitoring systems integrated into the plant central control system. Hence it is difficult to estimate the market price of a stand alone machine monitoring system for a plant. For this reason, the market size estimate shown in Table 6.1 only estimates the number of machines worldwide that may require monitoring in the hydrocarbon processing industry.

Table 6.1. Market size estimate for pump condition monitoring equipment in the hydrocarbon processing industry

Estimated number of pumps requiring CM	
Number of refineries worldwide (Billege, 2009)	700
Number of piece of large rotating equipment per refinery (Evans & Annunziata, 2012)	45
Total number of machines that potentially require monitoring equipment	31,500

6.4 Power Generation

Boiler feed pumps are critical pieces of equipment in thermal power plants. Larger more efficient power plants are choosing to use a single boiler feed water pump per boiler rather than smaller pumps in parallel (Rivas, 2007). This drives demand for reliability to ensure power plants maintain maximum availability.

Even more essential than pumps in power plants are electric generators. Since generators are in every power plant one could assume that the market size for generator condition monitoring would be larger than that of pump condition monitoring. Sulzer Dowding and Mills StatorMonitor technology may be suitable to applications in this area.

Carbon taxes combined with regulations promoting renewable energy power plants has led high growth in the renewable energy sector. The wind energy market has experienced particularly strong growth which is expected to continue over the next decade (U.S. Energy Information Administration, 2012). In the past, when the relative contribution of renewable power was less, conventional power plants produced a relatively steady base load for the grid while renewable power production topped up supply. Nowadays, renewable power is prioritised to fed the grid and is seen a variable base load (Pickard & Meinecke, 2011), while conventional power plants top up supply to meet demand. This supply regime has required better load following control of conventional power plants and has forced their average start-stop frequency to increase.

Higher start-stop rates of power plants consequently lead to higher fuel costs, maintenance costs (de Jong, van Abbema, Sjoerd Los, & van Dijken, 2010), and more frequent downtime (Eurelectric, 2011). For example, load following operation of nuclear power plants is expected to increase operating and maintenance costs by 2 % of the plants theoretical production capacity (Bruynooghe, Eriksson, & Fulli, 2010). Similarly, if a hard coal power plant were to undergo a daily start-up and produce peak power for 12 hours, start-up costs would be approximately 15 % of the total power generation costs (Kuntz & Müsgens, 2007). Hence interest in plant control and monitoring solutions to minimise operating costs has grown recently.

Another driver for machine monitoring in the power generation industry is the aging of infrastructure. Many conventional power plants will require additional maintenance as they age beyond approximately 30 years (The Federation of Electric Power Companies of Japan, 2007). Plan to increase the longevity of power plants often include upgrading equipment with modern technology and installing equipment to monitor the plants health.

6.4.1 Market Size Estimate

At present there are approximately 65,200 power plants operating around the world. Evans and Annunziata (2012) suggest that the majority of large instrumentable rotating equipment is installed in combined cycle power plants, of which there are 1,768 worldwide. Each of these plants will have at least one heat recovery steam generator (HRSG) which include at least one boiler feed water pump. Evans and Annunziata (2012) also state that the most common combined cycle configuration (2x1 configuration) has two gas turbines, two gas turbine generators, one steam turbine, and one steam turbine generator. There may also be machine monitoring opportunities associated with these machines. According to Joachim Schulz, head of Sulzer Pumps power generation business segment, previous quotes for gas and coal fired boiler feed pump monitoring packages have ranged between €25k – €50k. Table 6.2 provides a market size estimate for machine monitoring opportunities in the power generation industry based on these numbers.

6.5 Water

Marcos Koyama, head of Sulzer's water business segment, mentioned that condition monitoring is not regularly included in Sulzer's water production and transport business scope. He mentioned that customers and EPCs usually organise monitoring solutions themselves but sometimes specify that pumps supplied by Sulzer to be equipped with sensors. Similarly, customers sometimes request sensors for monitoring the pump motor drive which is usually an electric motor. Typically temperature, pressure, and vibration sensors are requested. However, most pumps are supplied without sensors. So in summary, Sulzer clean water condition monitoring is currently limited to supplying sensors requested by pump customers.

Table 6.2. Market size estimate for condition monitoring equipment in the power generation industry

Estimated number of pumps requiring CM (based on 1 boiler feed water pump per power plant)		
Number of combined cycle power plants worldwide (Evans & Annunziata, 2012)	1,770	
Number of nuclear power plants worldwide (International Atomic Energy Agency, 2012)	430	2,200
Estimated number of other rotating equipment requiring CM (based on 1800 2x1 combined cycle power plants)		
Number of steam turbines per plant	1	
Number of gas turbines water pumps per plant	2	
Number of generators per plant	3	10,800
Number of other large pieces of rotating equipment		13,000
Replacement market		
Average power plant design life [yr] (African Development Bank Group, 2008; Government of India, 2009; PB New Zealand Ltd, 2009)		25
Condition monitoring equipment installations per design life		2
Suggested average price of CM equipment [€] (conservative estimate)		25,000
Replacement Market [€]		26,000,000

Marcos concludes that Sulzer's lack of engagement in condition monitoring signal interpretation is a considerable barrier for customer support as well as an opportunity area for Sulzer to broaden its current offerings. Unfortunately this is also an area in which Sulzer lags its competitors who are providing levels of built-in intelligence into their smaller pumps. Competitors that offer 'smarter' small pumps include KSB, Grundfos, Wilo, and Xylem.

The acquisition of Cardo Flow Solutions in 2011 (Sulzer Ltd, 2011a) allowed Sulzer to complement its existing clean water solutions with waste water solutions from ABS (Figure 6.4). At present, waste water solutions is the most active business segment within Sulzer with regards to the development of pump controls and monitoring solutions. However, Per Askenström, Research and Development Manager for control and monitoring, states that while Sulzer waste water solutions were ahead of the competition 10 years ago, now they are behind. Currently they offer competitive products in the area of wastewater pump control and monitoring solutions. However, product sales are low (approximately 200 units annually).

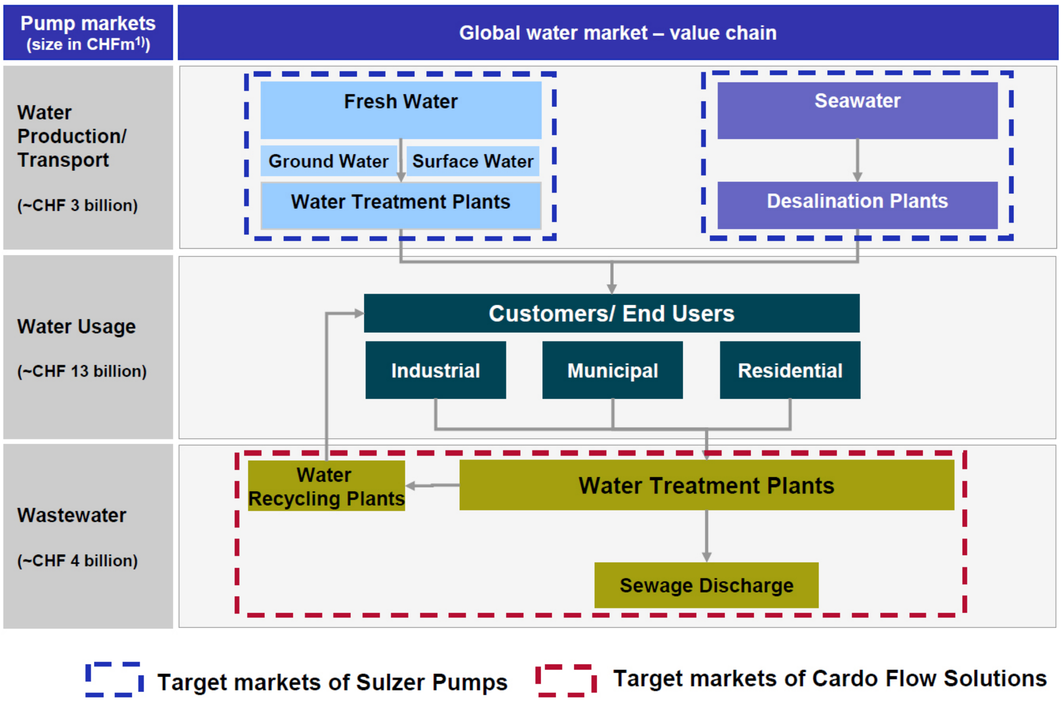


Figure 6.4. The acquisition of Cardo Flow Solution in 2011 complemented Sulzer's existing clean water market segment (Sulzer Ltd, 2011b)

Waste water solutions Product Manager, Jörgen Jäger, believes that the root cause of the hindered sales is with the salesmen tasked to sell these highly technical products. Most off the Sulzer sales force are trained to understand the technical aspects of pumps in order to sell pump equipment and services to Sulzer customers. Jörgen suggests that the current salesmen are under trained, and lack familiarity with control and monitoring products. This leads to salesmen having low confidence while discussing control and monitoring products with Sulzer customers.

6.5.1 Energy Regulations

Frank Ennenbach (Sulzer Pumps Germany) is heavily involved with the creation of energy regulations in Europe. He believes demand for condition monitoring in the water pump market is relatively small due to water pumps having slow wear rate. In contrast, energy consumption is a much bigger issue due to enforcement of European regulations. However, these regulations only apply to new pumps. Regulations governing ongoing pump operational efficiencies are not likely to appear in the near future due to the complexity of economic implications.

Once a pump is in service its efficiency will degrade with use and so some customers are interested in energy audits. However, pump focused energy auditing only addresses a small part of a systems energy expenditure. Frank believes that much greater energy savings could be made by conducting energy audits on entire pumping plants. Although this is logical, the cost and demand for such a service is not known. In addition to energy auditing, some customers may be interested in energy monitoring for cost saving, even though there are no regulations governing the sustainable operating efficiency of a pump.

6.5.2 Environmental Regulations

Wastewater collection systems ensure that sewage is properly collected, treated and discharged in a controlled manner to maintain a sanitary environment. Treated sewage discharge points are carefully selected to not affect clean water production and to have a minimal environmental impact. It is important that wastewater systems are properly controlled and maintained in order to avoid unwanted discharge of sewage also know as 'sanitary sewer overflows' (SSOs) which can contaminate clean water sources, damage property, and present public health risks. Hence regulations are often put in place to govern an acceptable frequency of SSOs. In the U.S. these regulations are enforced by the United States Environmental Protection Agency (2013) Environmental Protection Agency who may issue hefty fines to waste water system operators who do not comply. From 2003 to 2008 these fines amounted to $35m USD in the U.S. (Wheeler, 2008).

6.5.3 Market Size Estimates

Sulzer's head of business development for configured solutions, Marc Redit, estimated the market size for new water pump control and monitoring equipment to be approximately €77m with a replacement market size of approximately €102m. The calculation yielding these figures is included as Table 6.3.

6.6 Pulp and Paper and General Industry

Pekka Salmi of Sulzer Pumps Finland stated requests for condition monitoring are increasing in frequency, but energy consulting requests are approximately three times more frequent. The frequency of customer enquiries regarding energy audits is also increasing. However, energy audit sales are considered low.

Sulzer IntO condition monitoring devices and external sensors are mainly sold to other Sulzer companies rather than external customers. Total sales of IntO are estimated to be less than €100 000. To Pekka's knowledge there is no business plan associated with IntO. Currently IntO is mainly used within Sulzer as a tool for troubleshooting or collecting energy audit data. Pekka believes that their experience with the IntO monitoring device is why customers request energy audits from them. Due to the internal success of IntO, Sulzer Finland plans to develop a second generation IntO in collaboration with waste water service professional. They plan to market the second generation IntO much more heavily than the first to achieve more sales.

Niko Toikka (Service Manager for Sulzer Pumps Finland) states that energy auditing is becoming more popular in Finland as energy costs increase. When visiting customers, Niko and his team of service engineers almost always discuss energy usage and energy savings with them to promote the Sulzer brand and to increase their awareness of services offered by Sulzer. However, Niko has noticed that many customers are conducting their own in-house energy audits. However, generally customer executed energy audits are not as accurate as Sulzer energy audits.

Although rising energy costs provide good motivation for customers to conduct energy audits, Niko believes that the main reason customers hesitate is the significant amount of

Table 6.3. Market size estimate for waste water pump condition monitoring equipment (*Source: Marc Redit*)

Estimated number of pumping stations		
Number of pumping stations in large markets	60,000	
Number of large markets	10	600,000
Number of pumping stations in medium markets	40,000	
Number of medium markets	10	400,000
Number of pumping stations in small markets	10,000	
Number of Small Markets	45	450,000
Total number of pumping stations		1,450,000
Estimated number of controllers		
Percentage of pumping stations using this type controller		40 %
Total number of target controllers		580,000
Replacement market		
Life of typical controller [yr]		10
Replacement controllers per year [yr^{-1}]		58,000
Average cost per controller [€]		1,750
Replacement Market [€]		101,500,000
New equipment market		
Total Investment in WWC (Public Tenders) [€]		1,547,000,000
Percentage of content for controllers		5 %
New Equipment Market - Public Tenders [€]		77,350,000

resources energy audits require. Even if the auditing service is outsourced, the customer must provide personal to assist auditors with accessing in-house data systems. This is a problem since plants are typically aiming to reduce staff numbers to save cost.

In addition to reducing staff numbers in production plants, many paper factories aim to reduce the frequency of shutdowns for maintenance. Niko observed that in the past, when maintenance staff numbers were higher, maintenance issues were handled faster. At present, factories typically aim to run for a minimum of 1.5 years before shutting down for maintenance. During these long uptime periods many small issues arise that require urgent attention from technicians and hasty delivery of spare parts. Niko has noticed that even with large shutdown periods separating these long stints of uptime, maintenance planning is poor causing confusion with maintenance staff and parts suppliers. This poor maintenance planning is thought to be another consequence of inadequate staffing. Niko reports that customers say they simply do not have time to cover everything, i.e. running the plant, planning maintenance in detail and performing quick shutdowns. Niko also believes that hectic factory schedules also contribute to energy audit being delayed or cancelled.

6.6.1 Market Size Estimate

Head of CSS for Sulzer process pumps, Pekka Salmi, has estimated the initial market size for a low cost condition monitoring device similar to the IntO to be €9.4m based on the approximate number of process pumps in service (Table 6.4). He also estimates that an additional €1m - €3m could be accessible annually through installations on new equipment.

6.7 Market Attractiveness

To determine the vertical position of each Sulzer Pumps focus market on the Baaken matrix (see Figure 6.1), the attractiveness of each market was evaluated. This involved firstly establishing a set of evaluation criteria (Section 6.7.1), and secondly using the evaluation criteria to obtain an attractiveness index for each focus market (Section 6.7.2). Finally, Section 6.7.4 provides a summary of the perceived benefits and challenges present in each market.

Table 6.4. Market size estimate for process pump condition monitoring equipment (*Source: Pekka Salmi*)

Estimated number of pumps in need of CM	
Number of installed process pumps	250,000
Proportion of pumps in critical positions	15 %
Number of pumps in critical positions	37,500
Estimated CM market size	
Life of typical controller [yr]	10
Suggested average price of CM equipment	2,500
Market size	9,375,000

6.7.1 Market Attractiveness Evaluation Criteria

The attractiveness of each focus market for entry with machine monitoring business was evaluated through the following criteria:

1. Customer needs (20 %)

   How broad are customer needs in the market?

2. Competitive situation (20 %)

   How strong are competitors in the market?

   What are their strengths and weaknesses?

3. Legislation and regulations (17 %)

   Do present and future legislations and regulations promote business in the market?

4. Market feedback (17 %)

   How strong is customer demand for machine monitoring?

5. Standardisation (13 %)

   How tightly is the market controlled by standardisation?

6. Technology maturity (13 %)

   How mature is the technology currently on the market? Is there room for further development and innovation?

Some of the evaluation criteria were arguably more important than others. To account for this inequality, the most important were weighted 20 % higher than average, and the least important criterion were weighted 20 % less than average. These weightings are shown in brackets beside each of the criterion listed previously.

Of the six market attractive evaluation criteria list previously, customer needs and market feedback were considered the most important because they represent environmental factors that provide drive for a strong value proposition customer segment pair (see Section 4.4). Standardisation and technology maturity were considered to be the least important factors since they mainly influence the technical details of a value proposition and have little influence on business model design. The remaining criteria of legislation and regulations, and competitive situation were considered of neutral relative importance.

6.7.2 Evaluation of Market Attractiveness

To evaluate each market segment in terms of the criteria set out in Section 6.7.1, each of the Sulzer Pumps business segment heads were asked to complete a survey (Appendix C). The results of this survey are shown in Table 6.5. For each survey question, participants were asked to provide a ranking (i.e. low/moderate/high) and comment on their choice. These rankings were used to create an index for market attractiveness for each business segment. To do this, a 'high' (or 'strong') answer needed to be defined as a positive answer or a negative answer for each market attractiveness question. In Table 6.5 high positive questions are marked with H+ and high negative answers are market with H-. Next, a score was assigned to each response by assigning negative answers a score of 1, moderate or neutral answers a score of 2, and positive answers a score of 3. A total market attractiveness score was calculated for each business segment by summing all of the individual question scores. Finally, total scores were normalised by the total possible positive score to provide a market attractive index between 0 and 1. The scores and indexes for each business segment are shown in Figure 6.5 and Table 6.6.

Table 6.5. Survey results for evaluating of the attractiveness of market segments

Question	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
How broad are the machine monitoring needs of customers in your business segment? [H-]		●		High energy critical equipment (unspared) only
			◆	Most equipment in refineries etc has to be monitored but usually through clients central control system
			★	
	▲			Wastewater has a potential to be developed
	▼			Depending on product it moves up to strong! Small size collection network stations: low/weak, larger stations: strong. In treatment especially the compressors have high demands
	■			
How strong are machine monitoring competitors in your business segment? Please comment on their strengths and weaknesses. [H-]			●	
		◆		Monitoring suppliers would normally deal with end users
			★	
		▲		Xylem has an Analytics division that encompasses the whole process of water and wastewater treatment. With this they can leverage more businesses
		▼		Depending on competitor it ranges from low to strong
	■			Typically in process industry the monitoring / process control is process-wide regarding all standard pump & agitator applications. Our competitors do not typically have this in their project packages. Some individual products supplied e.g. by KSB for GI or CPI, but not yet in PPI

● – Oil and gas
◆ – Hydrocarbon processing
★ – Power generation
▲ – Water
▼ – Wastewater
■ – Process pumps (PPI/CPI/GI)

Continued on next page

Table 6.5. Survey results for evaluating of the attractiveness of market segments (continued)

Question	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
How strongly do future legislations and regulations promote machine monitoring business in your business segment? [H+]	●			
			◆	Health & safety plus environmental issues are high and will increasingly apply
			★	Please consider energy saving programs
	▲			Our solutions are oriented to lower life cycle (energy, maintenance)
			▼	Demands are steadily increasing
		■		More and more - we should look especially at the condition monitoring of individual pieces of equipment in critical applications
How strong is customer demand for machine monitoring in your business segment? [H+]		●		
		◆		We would normally provide terminal points and on skid equipment only, rarely the monitoring system
			★	Availability monitoring and MTBF control is very important
	▲			
		▼		This will most certainly change and increase
	■			Not often seen, not a major selling point or customer requirement. Naturally this could be a differentiating feature to secure good condition monitoring throughout the lifecycle, but it must be a cheap one

● – Oil and gas
◆ – Hydrocarbon processing
★ – Power generation
▲ – Water
▼ – Wastewater
■ – Process pumps (PPI/CPI/GI)

Continued on next page

Table 6.5. Survey results for evaluating of the attractiveness of market segments (continued)

Question	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
How strongly is the machine monitoring market controlled by standardisation in your business segment? [H-]		●		High energy critical equipment (unspared) only
			◆	API and similar established industry practices apply
		★		Depends on customers because the monitoring and control systems needs to fit into the customer IT system
	▲			
		▼		Machine monitoring demands as such are not strong today, but complete availability and efficiency demands are increasing. Therefore separate core item machinery monitoring demands will also increase
	■			Not seen yet
How mature is currently available machine monitoring technology in your business segment? [H-]		●		
			◆	Most plants well established and new grassroot refineries built to similar standards
	★			
	▲			Market potential needs development, it is un-regulated at the moment
		▼		The technology is available but not used to the extent it could
	■			

● – Oil and gas
◆ – Hydrocarbon processing
★ – Power generation
▲ – Water
▼ – Wastewater
■ – Process pumps (PPI/CPI/GI)

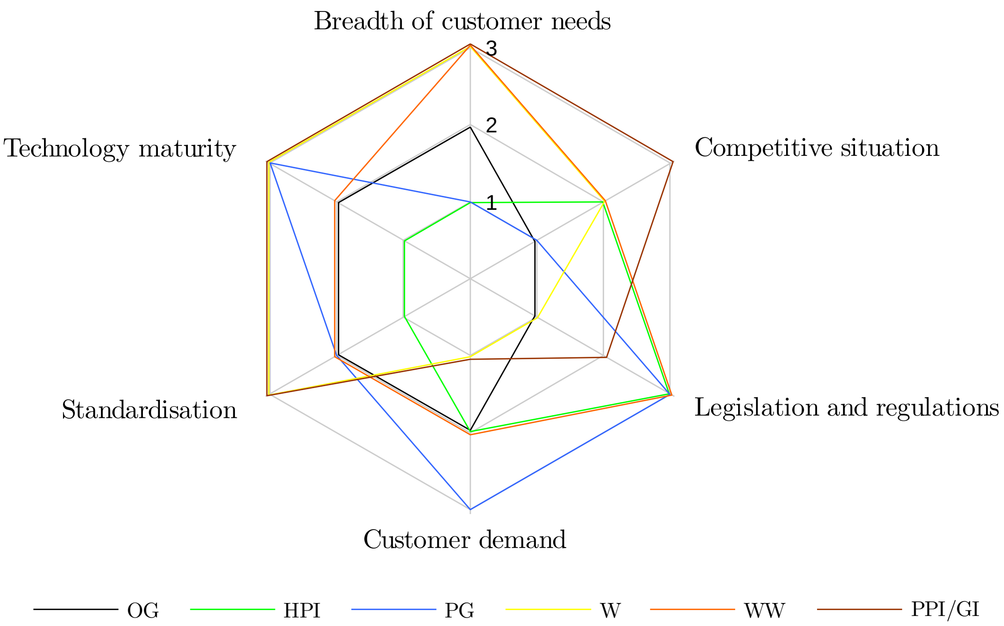


Figure 6.5. Machine monitoring market attractiveness for each of Sulzer Pumps business segments (higher numbers represents greater market attractiveness)

Table 6.6. Scores and indexes for machine monitoring market attractiveness in each of Sulzer Pumps focus markets

Market attractiveness Evaluation criteria	Weight	OG	HPI	PG	WPT	WW	PPI/ CPI/ GI
Breadth of customer needs	0.20	2	1	1	3	3	3
Competitive situation	0.20	1	2	1	2	2	3
Legislation and regulations	0.17	1	3	3	1	3	2
Customer demand	0.17	2	2	3	1	2	1
Standardisation	0.13	2	1	2	3	2	3
Technology maturity	0.13	2	1	3	3	2	3
Total Score		1.63	1.71	2.07	2.12	2.37	2.49
Market Attractiveness Index		0.32	0.36	0.54	0.56	0.69	0.75

6.7.3 Summary of the Business Segment Head Survey on Market Attractiveness

Water and process pump business segments both indicate that their customers have focused machine monitoring needs. However, customer demand in these segments is relatively weak compared to that in engineered solutions. Unfortunately, the higher demand for monitoring in engineered solutions also comes with stronger competition.

As expected, engineered solutions are strongly controlled by standardisation. However, unlike hydrocarbon processing and power generation, oil and gas does not see future regulations to promote machine monitoring business. Water business segment does not expect future regulations to promote machine monitoring business either.

Process pumps and water business segments view the current technology as immature and so new innovative solutions are more likely to be accepted in these markets. In contrast, engineered solutions already have relatively mature monitoring technology and established competition. Hence entry into the engineered solutions markets will be much more difficult.

6.7.4 Summary of Benefits and Challenges in each Sulzer Focus Market

The qualitative research presented in this chapter has been summarised in Table 6.7 to Table 6.11. These tables provide an overview of factors that should be considered for entering the machine monitoring market in each of the respective industries.

General industry was also considered as a potential focus market. However, due to the vast variety of general industrial pump applications, monitoring solutions suited to this segment would require extensive flexibility to cater for the large customer base. For this reason general industry was discarded as a potential focus industry segment for this study.

6.8 Sulzer Pump's Competitive Position

To determine the horizontal placement of each Sulzer Pumps focus market on the Baaken matrix (see Figure 6.1), Sulzer Pumps competitive position for machine monitoring business in each focus market was determined using the evaluation criteria set out

Table 6.7. Pros and cons for Sulzer entering the oil and gas industry machine monitoring market

Pros	Cons
• Other novel opportunities may be in demand. E.g. inline performance testing may be of more interest in the North sea than CM (Malcolm Watson) • Relatively large market size. Rich Niiranen estimates the market as approximately 1 %~3 % of the total market size of 5b USD. This is approximately 50m~150m USD • Sulzer Company's largest focus market • Good amount of retrofit business	• Well established competition. E.g. Dominant CM providers in the North Sea are SKF and XPD8 (Malcolm Watson) • GE has market dominance in this industry • Difficult entry into the market due to existing key competitors having large maintenance contracts • Existing CM in industry is not used to its full potential. Machines are often run to failure despite CM warnings (Malcolm Watson). It may be hard sell O&G customers something they don't use fully now. • Established industry reliability and safety standards may be a barrier to innovative developments

Table 6.8. Pros and cons for Sulzer entering the hydrocarbon processing industry machine monitoring market

Pros	Cons
• The HPI subsegment is the largest consumer of energy in the oil and gas industry. Hence energy monitoring opportunities may be available • There are a large number of pumps in each refinery, hence there is a large product installation base per customer	• Most plants are set up for central control and monitoring already due to tight constraints on environmental impact and health and safety issues • Customers in this segment are known to be secretive with process data. This makes it difficult to develop monitoring solutions • Currently a low priority for Sulzer CSS • Not much retrofit business in HPI. Replacements are more common

Table 6.9. Pros and cons for Sulzer entering the power generation industry machine monitoring market

Pros	Cons
• Experience with SUDIS and Smart-Monitor • Pumps are usually sold as a package with a motor, drive train, etc. The pump is usually only 30 % of the package value. This allows for more system monitoring opportunities • Many old power plants exist that are looking for lifetime extension opportunities • Big machines and high contract values • Relatively few regulations exist compared to O&G or HPI • A good level of technical assistance is available at power plants • Relatively low competency in instrumentation in India PG industry at present means there are good possibilities to add value here • SP Germany is looking for solutions at present	• Competitive market makes it difficult to obtain contracts • Monitoring should be integrated into central plant control systems • Not much has been done in terms of monitoring in the power generation industry which means that Sulzer will be pioneering new solutions

Table 6.10. Pros and cons for Sulzer entering the water industry machine monitoring market

Pros	Cons
• Established experience in pump controls and monitoring systems through ABS • Successful energy saving case studies are already published by Sulzer • Development in this industry would be aligned with Sulzer's most recent acquisitions. E.g. Cardo flow and Hidrotecar • Good growth in the smart water grid market is predicted by Frost and Sullivan: Average growth rate of approximately 8.5 % until 2020 (municipal utilities only)	• Water pump wear is lower than for other applications, and Sulzer pumps are already known to be reliable leading to lower demand for condition monitoring in this segment

Table 6.11. Pros and cons for Sulzer entering the pulp and paper industry machine monitoring market

Pros	Cons
• SPP Finland are already keen on developing solutions in this area (Pekka Salmi and team) • Redundant pumps are not common, so reliability is in high demand • Digital publishing is putting financial pressure on the PPI. Hence cost saving is important to them • Employee numbers in maintenance are dropping and so demand for reliability is increasing • Development in this industry is aligned with Sulzer's recent acquisition of Cardo Flow • Experience with condition monitoring in PPI has been gained through IntO	• Relatively small focus market of Sulzer • Relatively small pumps • PPI is predominantly a replacement market rather than a retrofit market

in Section 6.8.1. Note that Sulzer Pump's competitive position may rely heavily on experience gained through previous machine monitoring business (Section 3.6 and Section 3.10) and the experience gained through acquisitions. These two factors are considered in Sections 6.8.2 and 6.8.3 respectively. Finally, the competitive position of each Sulzer Pumps business segment is evaluated in Section 6.8.5.

6.8.1 Competitive Position Evaluation Criteria

To evaluate Sulzer's current competitive position for machine monitoring in each of the focus markets the following criteria were used:

1. Investment intensity (14 %)

   How strongly would Sulzer Pumps have to invest to enter the machine monitoring market?

2. Experience and knowledge (17 %)

   How developed is Sulzer Pump's experience and knowledge in machine monitoring?

   (a) Technology

   Has Sulzer got experience with popular technologies in the market?

   (b) Product development experience

   Has Sulzer developed solutions for machine monitoring before?

   (c) Service experience

   Has Sulzer offered monitoring services before?

   (d) Sales force

   Are Sulzer sales people currently knowledgeable in the area of machine monitoring?

3. Interaction with other business segments (12 %)

   How easily could technology developed for this market segment be applied in other market segments?

4. Customer loyalty (12 %)

   How strong is customer loyalty to Sulzer Pumps?

5. Market share (14 %)
   How high is Sulzer Pumps market share relative to our competitors?

6. Marketing strength (14 %)
   How frequently do customers show interest in machine monitoring in your business segment?

7. Keenness of Sulzer business segment (17 %)
   How keen is Sulzer Pumps to offer machine monitoring solutions in your business segment?

These evaluation criteria were weighted via the same method used to weight the market attractiveness criteria (see Section 6.7.1). Weighting are shown in brackets besides the evaluation criteria listed previously. Of the seven competitive position evaluation criteria, Sulzer's experience and keenness to offer machine monitoring were considered most important because they represent Sulzer's key resources and ability to perform key activities respectively. Hence these two factors reflect Sulzer's capacity to adapt to innovative future business models. Furthermore, they represent Sulzer's present capacity to make a machine monitoring offer.

Customer loyalty and business segment interaction were considered the least important factors contributing to Sulzer's competitive position, while investment intensity, current market share, and market strength were considered to have neutral relative importance. Market share, market strength, and customer loyalty are all factors which contribute to market forces which may drive a business model. However, market share and market strength were considered to be more direct indicators of the size and strength of market forces. The reason for this is that the known customer loyalty to Sulzer's Pumps current products and services may not accurately indicate the loyalty of customer to new offerings from Sulzer Pumps. Business segment interaction is not of immediate importance since Sulzer will focus firstly on executing a successful business model in one business segment only. However, once a machine monitoring business has been established business segment interaction will be become more important to diversify offerings. Investment intensity is an important financial factor, however, it is a factor that is predominantly governed by forces within Sulzer company, and less so by the business model environment.

6.8.2 Recent Sulzer Acquisitions

The acquisition of Dowding and Mills by Sulzer Turbo Services in 2010 diversified Sulzer's experience in condition monitoring to include monitoring of electric motors. Sulzer Dowding and Mills currently use StatorMonitor and MotorMonitor technologies as tools to offer monitoring services predominantly in the oil and gas market. Although this business does not fall under Sulzer Pumps it does add to the machine monitoring knowledge of Sulzer Company.

In 2011 Sulzer Pumps acquired Cardo Flow Solutions, which diversified its offerings to include waste water products. This event increased Sulzer companies water segment sales share from 5 % to 16 % (Sulzer Ltd, 2011b), and also increased the water segment sales share within Sulzer Pumps (Figure 6.6). Moreover, it was expected that the water segment would become Sulzer Pumps largest market after the acquisition (Sulzer Ltd, 2011b). As part of this acquisition, Sulzer Pumps acquired the ABS brand name and product line which included control and monitoring solutions.

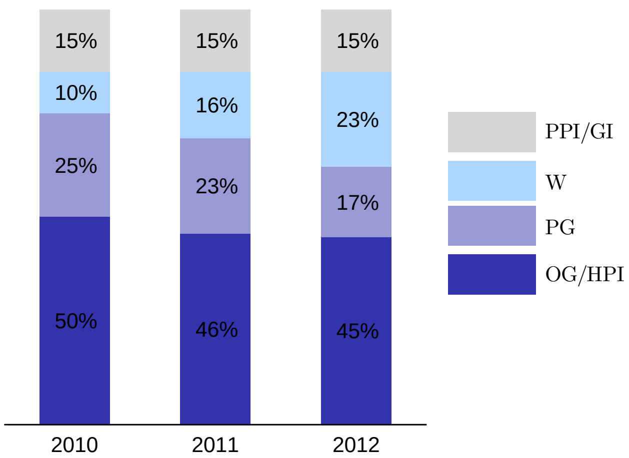


Figure 6.6. Sulzer Pumps sales by market segment (*Source: Sulzer Ltd (2013f)*)

6.8.3 Summary of Sulzer's Experience in Monitoring within each Sulzer Focus Market

While Sulzer has had a range of technical and commercial experiences with condition monitoring equipment and services, this experience is restricted to certain industries. Table 6.12 provides a summary of Sulzer's experience in supplying machine monitoring equipment and services for each of Sulzer Pumps business segments.

At present, Sulzer Pumps waste water is the only business segment that offers monitoring equipment (i.e. ABS control and monitoring equipment). Sulzer Pumps oil and gas, and process pumps business segments currently offer monitoring services that rely on StatorMonitor and IntO technologies respectively. Note that two of these offerings are the results of Sulzer acquisitions rather than internal research and development. To get the most value from these acquisitions and Sulzer Pumps internal research and development work it would be logical for Sulzer to focus its future development efforts in the oil and gas, water, or process pump business segments.

Sulzer did have three patents protecting SUDIS and SmartMonitor technology. However, these patents expired in 20119. Sulzer Pumps has no patents for its present waste water pump monitoring and control solutions.

Table 6.12. Summary of Sulzer past and present machine monitoring offerings

Business segment	Past offers	Current offers	Suggested developments	Current or ongoing R&D
OG		StatorMonitor*/ MotorMonitor*		
HPI				
PG	SUDIS/ SmartMonitor			Blackbox monitor
W		ABS Pump monitor and controller (PC 441)	Sulzer modular control and monitoring system	
PPI/GI	IntO		IntO 2	

* Offered by Sulzer Turbo services. All other offerings are from Sulzer Pumps

6.8.4 Readiness of Sulzer Pumps Products

In the early twentieth century, monitoring of pumps was limited to measurements of suction and discharge pressures. As efficiency and reliability became important features or high energy pumps more sophisticated monitoring solutions became more common. Now there are five basic properties that are normally measured at various locations on a pump (Figure 6.7). These properties are: temperature, vibration (or displacement), pressure, flow and level (Bennan, 2011).

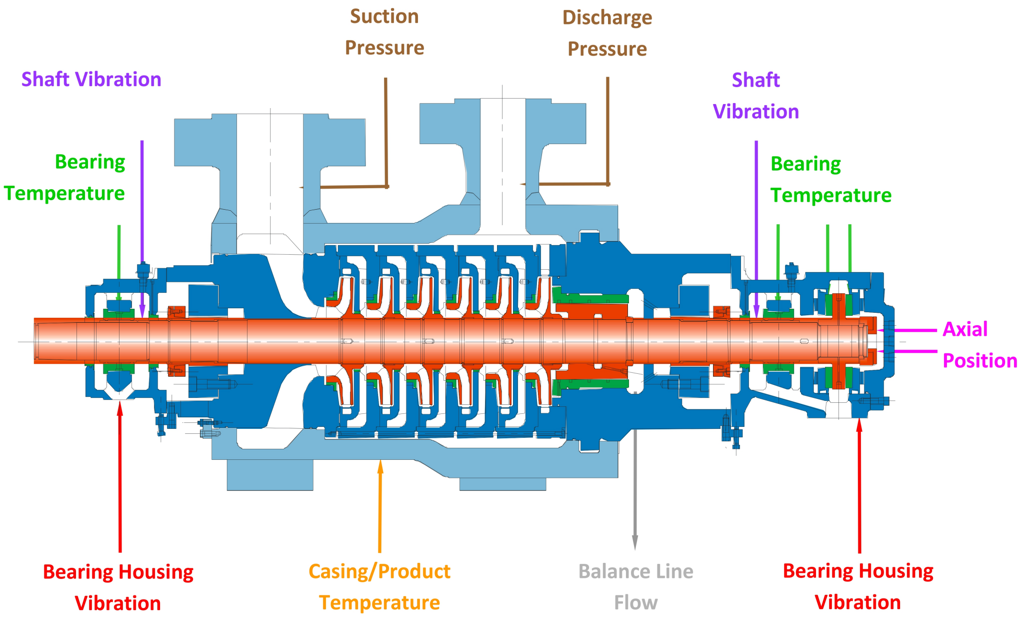


Figure 6.7. The five basic monitoring parameters for pumps. (*Source: Bennan (2011)*)

Controls and instrumentation manager for Sulzer Pumps UK, Tony Brennan, says that the majority of engineered solutions manufactured in Leeds, UK, are supplied with instruments according to industry standards, such as API 670 in the oil and gas industry. Instrument signals are usually interpreted and displayed by a central supervisory control and data acquisition (SCADA) system. However, some pumps may also have their own unit control panel (UCP) in addition to a connection to the central control system. Sulzer does not currently offer any control or data acquisition systems but does supply UCPs assembled with competitor products. It is common for customers who request control and data acquisition equipment to specify products that are highly compatible with common proven software solutions such as General Electric's System 1 or Emerson's DeltaV SCADA system.

Antonio de Torre, portfolio manager for Sulzer Pumps water segment, states that the instrumentation supplied with water pumps change from project to project and depend on the customer requirements. However, all Sulzer water pumps can accommodate the sensors listed in Table 6.13. Sulzer Pumps can also provide mechanical seal leakage detection, although requests from customers are seldom. When instrumentation is supplied with water pumps, both pump and motor sensors are wired to a common junction box on a common baseplate where the user may connect their distributed control system (DCS).

6.8.5 Evaluation of Sulzer Pumps Competitive Position

Similarly to the market attractiveness evaluation, the competitive position of each Sulzer Pumps business segment was evaluated against the criteria in Section 6.8.1. This evaluation was also done through a survey distributed to the Sulzer Pumps business segment heads (Appendix C). The results of this survey are shown in Figure 6.8 and Table 6.14.

Table 6.13. Sensors that may currently be supplied with Sulzer water pumps at the request of customers

Device	**Position**	**Measurement Parameter**	**Sensor Type**
Pump	Bearings	Temperature	PT-100 RTD
	Bearings	Vibration	Accelerometer
	Suction flange	Pressure	Pressure transducer
	Discharge flange	Pressure	Pressure transducer
Motor	Bearings	Temperature	PT-100 RTD
	Bearings	Vibration	Accelerometer
	Windings (3x2)	Temperature	PT-100 RTD

Table 6.14. Survey results for evaluating of Sulzer's competitive position by market segment

Question	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
How strongly would Sulzer Pumps have to invest to enter the machine monitoring market in your business segment? (Please consider the breath of the current product line, patented technology, current product developments, etc) [H-]			●	
			◆	We would need to buy someone
			★	
		▲		Our wastewater business sees the potential of applying control and monitoring specially in wastewater collection pumping stations. Some of our products in wastewater treatment has some built-in control and monitoring (high speed turbo-compressors)
	▼			Investments are divided into one side R&D and the other in training for both sales and service
		■		We should first have a proper knowhow network externally to support us in this, and it should be a part of PD stage case processes to evaluate the needs. Also CSS should look the opportunity based on installed base
How developed is Sulzer Pump's experience and knowledge in machine monitoring within your business segment? Please comment on experience in product/service development, technology, sales, etc. [H+]	●			
	◆			Not such a great demand from the pump suppliers. See earlier comments in Table 6.5
	★			
		▲		Only our wastewater business has developed C&M solutions. These solutions are evaluated as very good and with growth potential, however growth is not being realized yet for several reasons related to marketing strategy
		▼		This varies very much from sales company to sales company and region
	■			We have had the monitoring prototyping in the past years, but not with a high volume and success. Due to reasons explained earlier

● – Oil and gas
◆ – Hydrocarbon processing
★ – Power generation
▲ – Water
▼ – Wastewater
■ – Process pumps (PPI/CPI/GI)

Continued on next page

Table 6.14. Survey results for evaluating of Sulzer's competitive position by market segment (continued)

Question	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
How transferable would machine monitoring technology, developed for your business segment, be to other business segments? Please comment on your choice. [H+]	●			
		◆		If developed could be used in oil and gas, power generation, etc
			★	
		▲		It seems to be of little use for the engineered solutions, but eventually can be incorporated into other products of configured solutions
			▼	Some demands vary but most can be reused
		■		Depend on measurements needed, partially possible
How strong is customer loyalty to Sulzer Pumps in your business segment? [H+]			●	
		◆		Generally it is strong with the end users....but we have to perform to maintain this and often we let ourselves and customers down due to poor delivery etc. Contractors are more fickle
		★		
		▲		End customers will look for solutions that improve their operations and especially reduce their OPEX
			▼	Rather strong but considering the market share we have a vast potential
			■	Very high, especially in PPI in those areas where we have strong position. Also within our large OEMs

● – Oil and gas
◆ – Hydrocarbon processing
★ – Power generation
▲ – Water
▼ – Wastewater
■ – Process pumps (PPI/CPI/GI)

Continued on next page

Table 6.14. Survey results for evaluating of Sulzer's competitive position by market segment (continued)

Question	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
How high is Sulzer Pumps market share relative to our competitors in your business segment? [H+]			●	
			◆	In our served market (engineered centrifugal pumps) we are number 2
	★			
	▲			
	▼			From a total world market, only approximately 5 %~8 %
			■	Depends on geographical area. Globally strong in PPI, varies in GI, very small (< 1 %) in CPI
How frequently do customers show interest in machine monitoring in your business segment? [H+]	●			
	◆			Very rarely
			★	Tendency is to invest in one 100 % pump which has to be controlled and monitored
	▲			
		▼		Very few sales companies even mention our possibilities in their segment due to lack of knowledge or uncertainty
	■			Very seldom, key criteria are price, delivery time and product reliability. The last one is synergic to this approach

● – Oil and gas
◆ – Hydrocarbon processing
★ – Power generation
▲ – Water
▼ – Wastewater
■ – Process pumps (PPI/CPI/GI)

Continued on next page

Table 6.14. Survey results for evaluating of Sulzer's competitive position by market segment (continued)

Question	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
How keen is Sulzer Pumps to offer machine monitoring solutions in your business segment? [H+]	●			
	◆			Main focus will be on selling the pumps themselves...in addition to the value of the sale it is also the pump that will generate future spare parts
	★			
		▲		At the moment we do not look beyond wastewater applications and even in wastewater we are limited to wastewater collection
	▼			See previous answer
	■			We have to solve first the other major obstacles, such as product cost, delivery timing etc

● – Oil and gas
◆ – Hydrocarbon processing
★ – Power generation
▲ – Water
▼ – Wastewater
■ – Process pumps (PPI/CPI/GI)

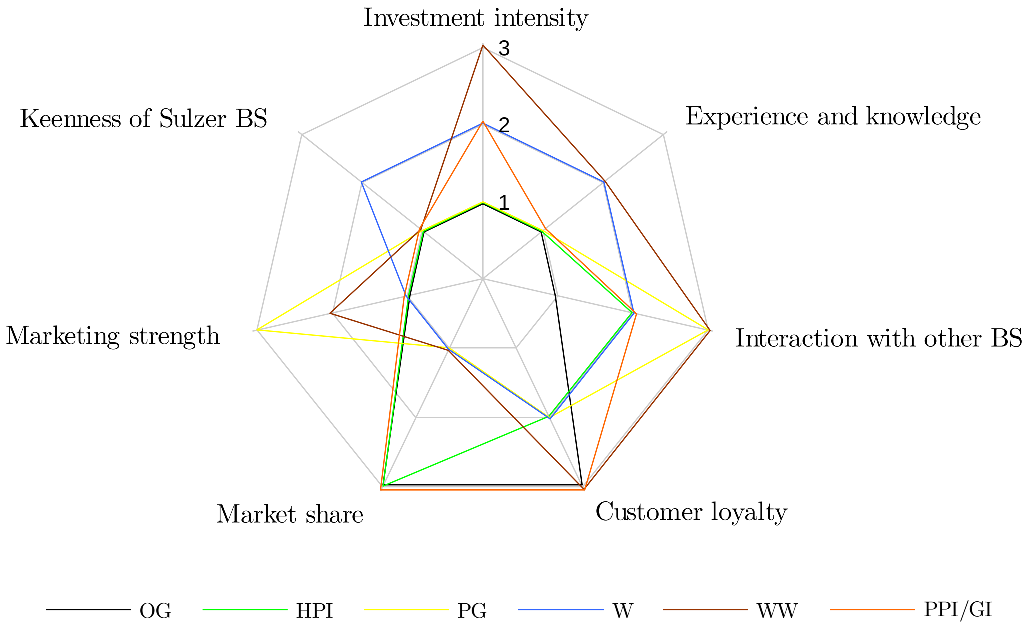


Figure 6.8. Sulzer's competitive position in machine monitoring markets (higher numbers represents greater competitiveness)

6.8.6 Summary of the Business Segment Head Survey on Sulzer Pump's Competitive Position

Sulzer Pump's lack of machine monitoring experience is reflected in the survey results where only the water business segment claimed a moderate amount of machine monitoring knowledge. All engineered solutions business segments rated their experience and knowledge as low and confirmed that they would need to invest heavily to offer monitoring solutions. This is not surprising since engineered monitoring solutions may require significantly more development than configured monitoring solutions.

Interestingly, the majority of business segment heads indicated in the final question of the survey that Sulzer Pumps had a low drive to offer machine monitoring solutions (Table 6.14). Only the water business segment indicated moderate interest in engaging in this area of business. Results also show that the keenness of a business segment to offer machine monitoring solutions is proportional to the segments experience and knowledge.

This is an intuitive yet important factor to take into account for selecting a business segment to continue development in.

Oil and gas and hydrocarbon processing business segments tended to score high in criteria that were weighted low, while water business segment benefited most from the weighting system (Table 6.15). This said, the weighting system was deemed fair and favoured neither engineered nor configured solutions. Moreover, the weighting system did not significantly affect the outcome of the survey.

Table 6.15. Scores and indexes for Sulzer's competitive position in machine monitoring markets

Sulzer competitive position Evaluation criteria	Weight	OG	HPI	PG	WPT	WW	PPI/ CPI/ GI
Investment intensity	0.14	1	1	1	2	3	2
Experience and knowledge	0.17	1	1	1	2	2	1
Interaction with other BS	0.12	1	2	3	2	3	2
Customer loyalty	0.12	3	2	2	2	3	3
Market share	0.14	3	3	1	1	1	3
Marketing strength	0.14	1	1	3	1	2	1
Keenness of Sulzer BS	0.17	1	1	1	2	1	1
Total Score		1.52	1.52	1.64	1.72	2.07	1.78
Competitive Position Index		0.26	0.26	0.32	0.36	0.54	0.39

6.9 Evaluating Market Profitability

In addition to market attractiveness and Sulzer's competitive position, the profitability of machine monitoring offerings in each market was considered. To estimate the profitability of each market segment, it was assumed that the machine monitoring profitability of a market segment was proportional to the average profitability of the respective industry. Table 6.16 shows the average net profit margin as a measure of profitability for industry representing each market segment.

Table 6.16. Net profit margins for Sulzer Pumps preferred industries

BS	Industry	Average Net Profit Margin
OG	Oil & Gas	8.7
	(Drilling and exploration, equipment and services, and pipeline subsegments average)	
HPI	Oil & Gas	2.9
	(Refining & Marketing)	
PG	Electric Utilities	4.1
W	Water Utilities	13.2
PPI/GI	Paper & Paper Products	1.8

(Data source: Yahoo Finance industry averages as at 14 March 2013)

6.10 Selecting Focus Market Segments

In the following subsections several arguments are put forward to favour certain business segments for the remainder of this study. From these arguments two business segments were selected to focus the present study on. This selection procedure was necessary to limit the timeframe of the investigation.

6.10.1 Support of Recent Sulzer Acquisitions

In recent years Sulzer Company has made two large acquisitions amongst several smaller ones (see Section 6.8.2), both of which included machine monitoring technologies. These technologies are primarily targeted at the oil and gas, power generation, and waste water markets. To obtain the best return on these investments it is recommended that the acquired technologies be exploited in their intended markets as well as being adapted to customer requirements in similar markets. By making the most of technology that is presently available, Sulzer may maintain low development costs and maximise profits. Hence it is recommended that immediate machine monitoring business development be focused in the oil and gas, power generation or water market.

6.10.2 Risk Minimisation

Sulzer Pumps current machine monitoring business is positioned in the undesirable lower left corner of the Boston Consulting Group (BCG) matrix (Henderson, 1970) (Figure 6.9) due to a combination of investing machine monitoring research and poor sales of current product and services. An ideal movement for Sulzer's machine monitoring product portfolio would be diagonally right and down, i.e. increasing sales while decreasing the cost of goods sold. This movement may represent the typical outcome of programs designed to increase business efficiency.

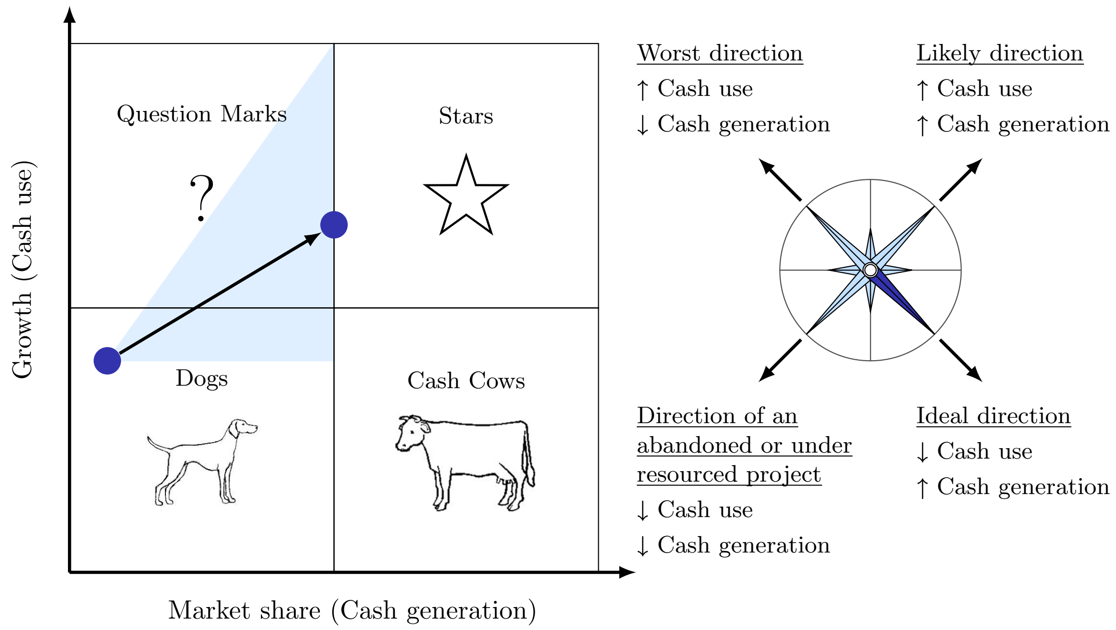


Figure 6.9. The position of Sulzer's machine monitoring solutions portfolio with a suggested development path

A more likely path for Sulzer Pumps is to the left and up which represented further investment and increased sales. However, moving upward also represents more risk. The machine monitoring markets have significant barriers to entry which have yet to overcome by Sulzer Pumps. After several unsuccessful attempts to enter the machine monitoring market (see Section 3.6), it would be wise to keep risk associated with future attempts to a minimum. To limit risk, movements on the BCG diagram should be kept as horizontal as possible. This can be done by favouring business segments that have low investment intensity. For Sulzer Pumps these are the configured solutions markets (Figure 6.8).

6.10.3 Sulzer Pumps Current Install Base

It is difficult to estimate the value of installed pumps due to sales values in the ERD data base having various currencies and sales dates. So pump power, a variable that does not change with time or location was used to visualise the Sulzer Pumps install base. Note that pump power is assumed to be proportional to pump size, complexity, and value. Figure 6.10 shows the number of installed Sulzer Pumps for given ranges of pump rated input power. Note that there is a higher probability that pumps disposed off without notifying Sulzer with small pumps than with large pumps. Hence the uncertainty of the small pumps data would be higher than uncertainty in the large pumps data.

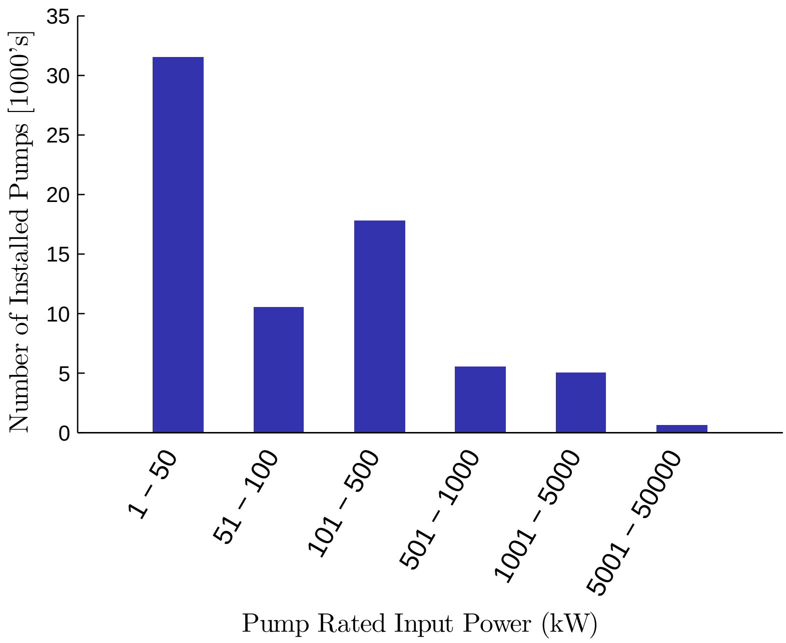


Figure 6.10. Number of installed Sulzer pumps by pump rated input power (*Source: Sulzer ERD*)

6.10.4 Market Attractiveness and Sulzer's Competitive Positions

The Baaken matrix in Figure 6.11 summarises the attractiveness of each Sulzer Pumps focus market for machine monitoring business. It plots Sulzer's competitive position index (see Section 6.8) against the market attractiveness index (Section 6.7) and displays the estimated market profitability (Section 6.9) through circle size. Markets in the top right hand side of the diagram are more favourable for Sulzer Pumps to pursue machine monitoring business in than markets in the bottom left hand side. Hence the business segments of water, power generation and process pumps are arguably the best business segments for Sulzer Pumps to focus development in.

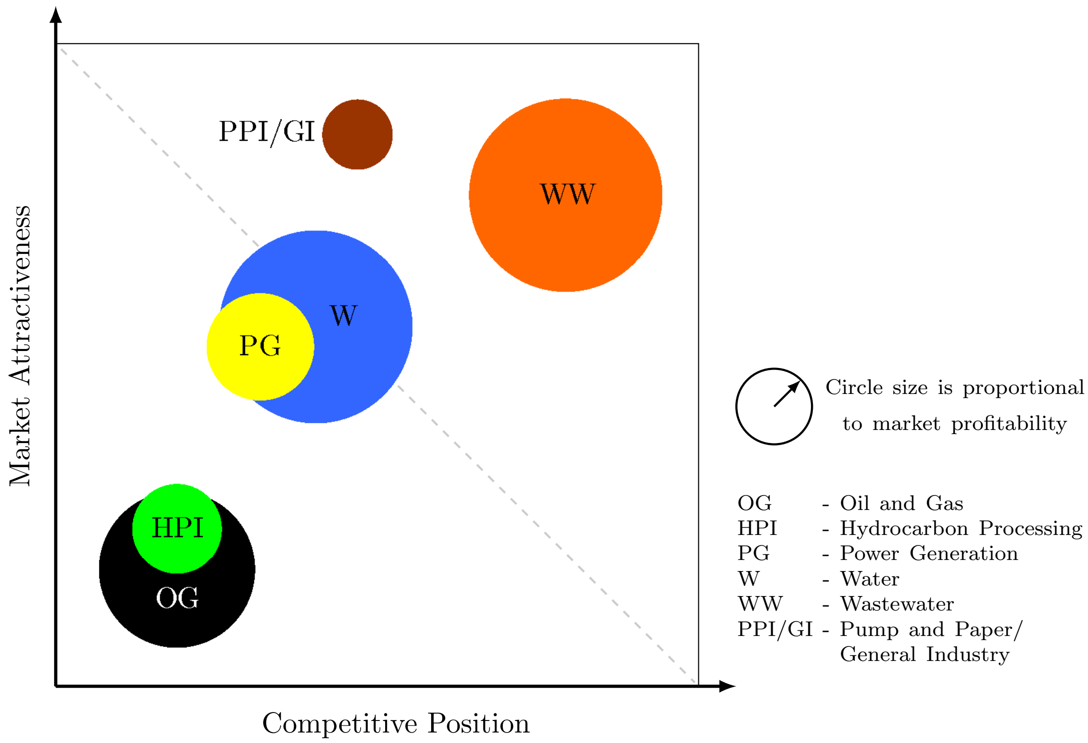


Figure 6.11. Sulzer competitive position versus market attractiveness for machine monitoring in Sulzer Pumps focus markets

Although power generation is clearly the most attractive engineered solutions market, determining the most promising configured solution is more difficult since the process pump market is more attractive but the water pump market may be more profitable. In this case, profitability is considered the more important factor since it will promote growth in Sulzer's monitoring business. Hence the water market is favoured over the process pumps market for machine monitoring business developments.

6.10.5 Focus Market Selection Summary

By considering the arguments in the previous subsections, power generation is deemed the best of the three engineered solutions market to develop machine monitoring offering in. This outcome is largely due to the market trend of customers investing in single 100 % boiler feed pumps that must be monitored, and low market competition relative to other engineered solutions markets. Development of power generation monitoring business may also support recent acquisition decision of Sulzer Company.

Both configured solutions markets are attractive for machine monitoring business. However, the water market was decided the more promising of the two. The main reasons behind this decision is that machine monitoring business in the water market is likely to be more profitable than machine monitoring in the process pumps market (Table 6.16), and Sulzer Pumps has invested heavily in its water business segment in the recent years (see Section 6.10.1).

6.11 Summary

In this chapter, firstly each Sulzer Pumps focus market was introduced with its common machine monitoring applications. Next, key drivers and challenges were identified in each market to provide a qualitative perspective on the present machine monitoring business environment. This environmental review was supported with a survey that evaluated Sulzer Pumps competitive position within each focus market and the attractiveness of each focus market.

Survey results showed that the business segments of power generation, water, and process pumps (i.e. pulp and paper, chemical processing, general industry, etc) would be most attractive for Sulzer to pursue machine monitoring business in (Figure 6.11). Of these business segments, power generation and water were recommended for further investigation since they have more favourable profitability than the process pump market. This recommendation also leaves the scope of this study open to either engineered or configured solutions.

Chapter 7

Selecting Focus Market Subsegments

7.1 Introduction

Sulzer produces a large range of pumps designed for a variety of applications. Centrifugal pumps are classified by a combination of the pump design features, namely its orientation, type, casing split line, feet arrangement, nozzle type, nozzle arrangement, bearing arrangement, and main axis orientation. Within a particular industry several pump types may be used for different applications. For example, Figure 7.1 shows the different types of pumps that are employed within the pulp and paper industry alone.

As mentioned in Section 3.12, the application of a pump is likely to affect the operators need for monitoring equipment or services, and in Chapter 6 the two most attractive Sulzer Pumps focus markets for machine monitoring business were identified as the power generation market (most attractive engineered solutions market) and the water market. Within either of these two markets lies a broad range of applications machine monitoring. In this chapter, these two industries are investigated further to identify and evaluate specific opportunities within market subsegments. In addition, machine monitoring business opportunities in the pipeline industry are also investigated.

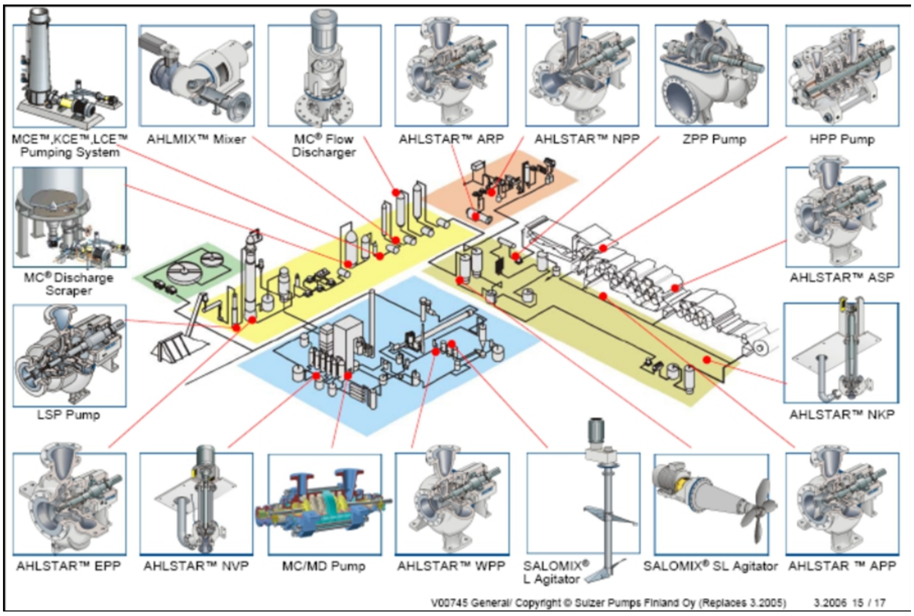


Figure 7.1. Pumps in the pulp and paper industry (*Source: Sulzer Pumps Finland OY (2006)*)

7.1.1 Objective

The primary objective of the work presented in this chapter was to identify the business model environment for machine monitoring opportunities within the water, power generation, and pipeline industries. The second objective was to identify specific value proposition and customer segment pairs for machine monitoring business opportunities in either of these industries. The results from this chapter will form the basis for concept business models presented in Chapters 8 and 9.

7.1.2 Method

To achieve the objectives mentioned previously, value chains for the water and power generation industries were constructed and used to highlight where Sulzer's current business lies. It is in these segments where machine monitoring opportunities will be most easily realised. Next, market trends and drivers for each industry were found by reviewing current news, regulations and statistics. This allowed for high growth segments in the value chain to be identified as segments where Sulzer may gain a market share most easily.

Within each promising market segment, the most unreliable or energy consuming assets were identified as opportunities were Sulzer may add value with machine monitoring solutions. To evaluate the attractiveness of each opportunity, the current competition was reviewed and the total market size was estimated. Sulzer's current market position and ability to create value were also considered. Finally, customer segments were identified for the most attractive value propositions.

7.2 Segments of the Power Generation Industry

Figure 7.2 shows the two main subsegments in the power generation market value chain are electricity generation and district heating. Both of these segments contain pump applications and therefore potential pump monitoring opportunities. However, the value chain of district heating is arguably more dependent on pump reliability and efficiency than the value chain of electricity production since it relies totally on fluid transport. Hence Sulzer Pumps may have more machine monitoring opportunities in the district heating segment than in the electricity generation segment. Nevertheless, the much larger size of the electricity generation market compared to that the district heating market may contradict this hypothesis. The following subsections analyse these market with the aim of identifying the most valuable machine monitoring opportunities around pumps and other common machinery.

7.2.1 Electricity Generation

Figure 7.3 shows several ways that energy sources are converted to electrical energy. It shows that anywhere between one and three energy conversions take place before electrical energy is obtained. Intuitively, more energy conversions require a greater variety of equipment to produce electricity, and hence more machine monitoring opportunities are likely to exist. For example, the simplest method for electricity production is the direct conversion of solar radiation into electricity via photovoltaic cells. This process does not require any rotating equipment and so machine monitoring opportunities here are low. In contrast, thermal power plants require three energy conversions to produce electricity and so machine monitoring opportunities are more abundant.

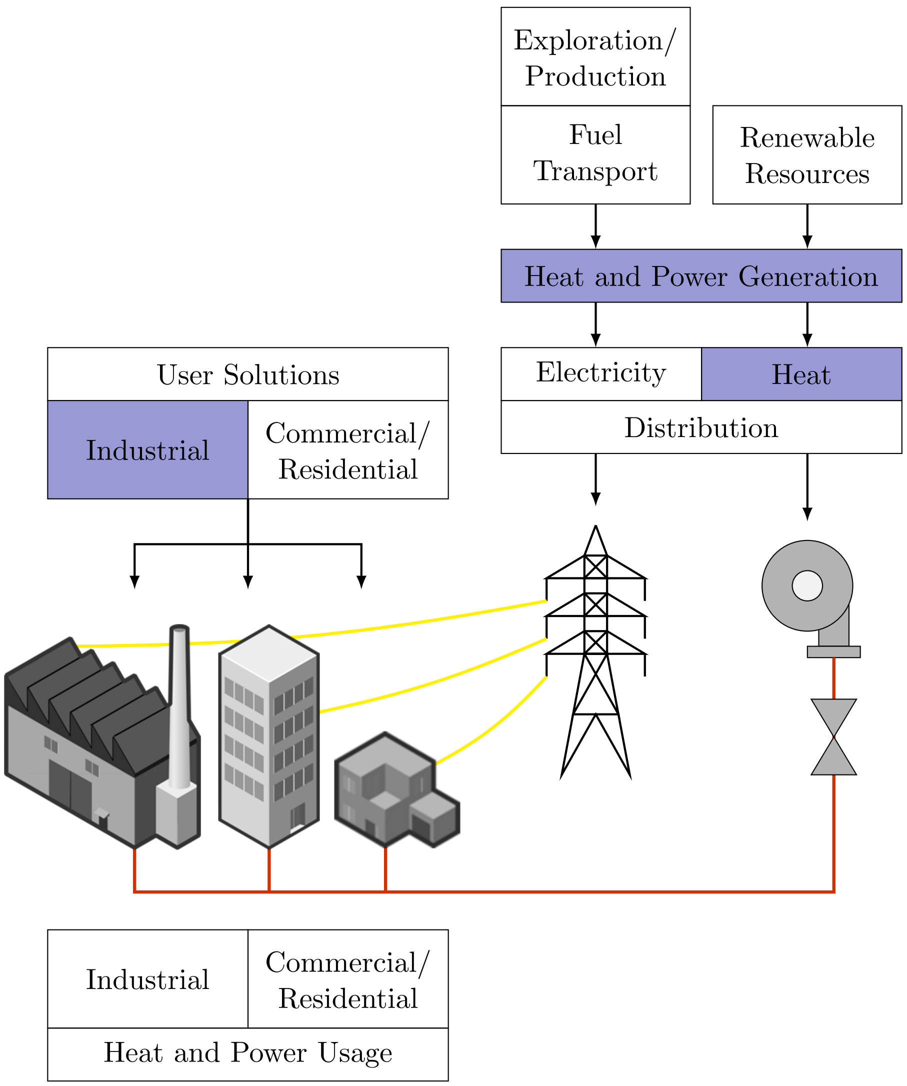


Figure 7.2. The value chain for heat and power market (Sulzer is currently involved in processes marked in blue)

All methods of electricity production (with the exception of photovoltaic cells) convert source energy into mechanical shaft power, which is then converted into electrical power via a generator. Hence, electric generators may be considered the bottle neck of electricity production and are arguably the most important piece of equipment in the value chain. In contrast pumps may be considered relatively unimportant in electricity production since many technologies can function without them. Moreover, most pump monitoring opportunities will be limited to electricity production methods utilising thermal energy

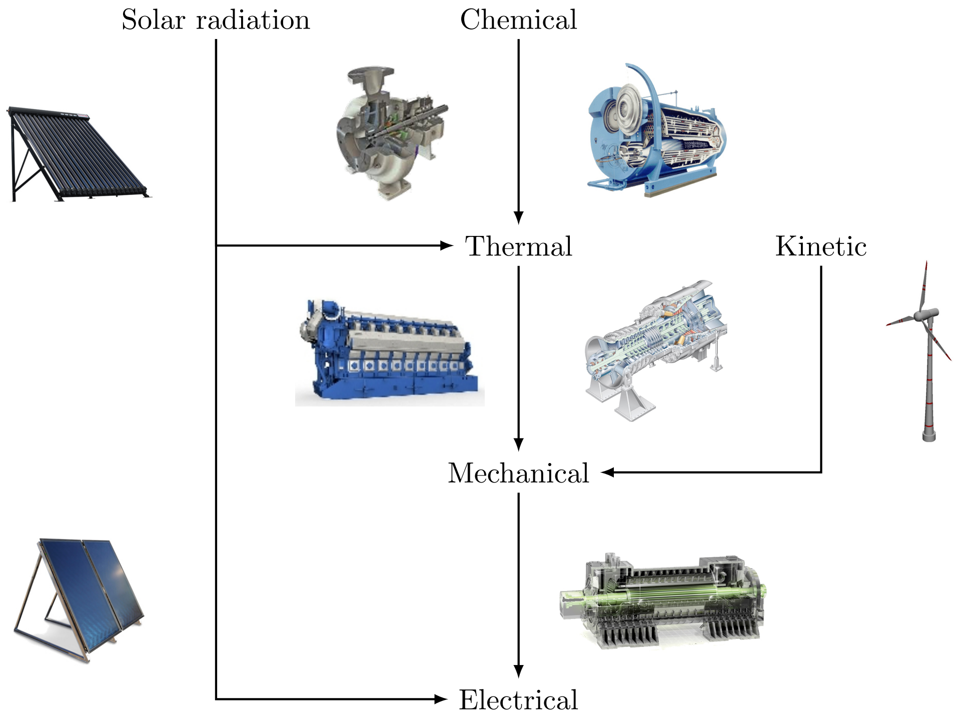


Figure 7.3. Energy conversion methods for electrical power generation

since this is where pumps are used most (e.g. for transport of water and steam).

Due to this inherent limitation of the pump monitoring market size in the electricity generation segment, the following subsections investigate both pump and non-pump machine monitoring opportunities. Although Sulzer Pumps may not have interests in machine monitoring markets that do no involve pumps, other Sulzer divisions such as Sulzer Turbo Services (see Section 2.2) may have interests in these markets.

Electricity Generation around the World

Over the past three decades world electricity production has increased by a factor of 3.5 times (International Energy Association, 2012), and during this time, electricity generation shares of each fuel have changed significantly (Figure 7.4). For example, the share of electricity produced from nuclear energy has trebled, and that produced from renewable energy sources (excluding hydropower) has increased by a factor of 5 times. Figure 7.5 shows an overview of the current world electricity production capacity by technology and plant size.

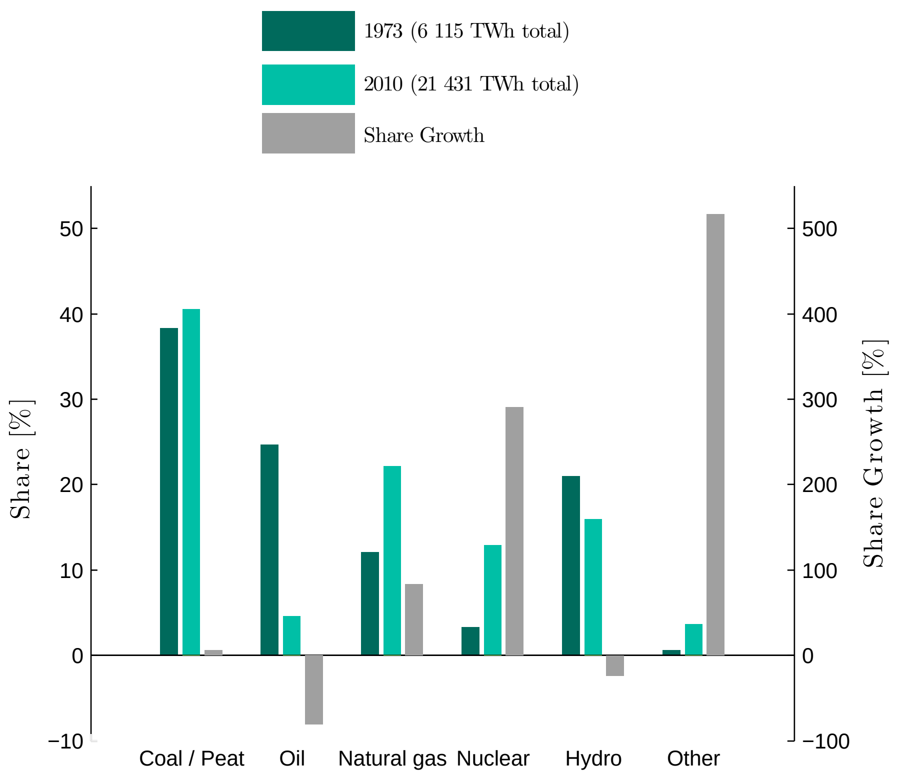


Figure 7.4. World electricity generation by fuel type, 1973-2010 (*Data source: International Energy Association (2012)*)

Recent strong growth in the share of renewable energy sources is driven predominantly by the widespread adoption of wind power technology in the U.S., Europe and China. The U.S. Energy Information Administration expects this trend to continue, and has forecasted strong growth in the world wind energy capacity for the next two decades (Figure 7.6). Electricity production in China has grown rapidly over recent decades and now makes up nearly 20 % of worldwide production (International Energy Association, 2012). Over the next two decades electricity production capacity is expected to double, taking the Asian world share in electricity production from 35 % up to 48 % by 2030 (Figure 7.7) (du Pont, 2011). As with the world trend shown in Figure 7.4, Coal will remain the dominant fuel for electricity production in Asia of the next two decades. However, the share of coal power plants is expected to shrink from 69 % to 59 % as the share of gas, and other energy sources (such as biomass and water) increases.

The future for nuclear power production is uncertain. After the 2011 tsunami in Fukushima, Japan, some countries are rethinking their nuclear power generation plans. Germany plans to close all of is nuclear power plants by the year 2022 (Dempsey & Ewing, 2011), initially favouring coal power to maintain capacity (Nicola, 2013). Similarly, Switzerland has chosen to slowly phase out nuclear power by 2034 in favour of renewable energy (Geiser, 2011). Under public pressure Japan also decided to phase out nuclear power by 2030 (Inajima, Y., & Okada, 2012). In contrast, many countries remain pro-nuclear including the world's largest nuclear energy producers, France, Russia, and the U.S..

In the U.S., goals of the Federal Energy Regulatory Commission (FERC) include allowing renewable electricity generation technologies to compete fairly in the market in order to reduce carbon emissions (Federal Energy Regulatory Commission, 2013b). The Commission's firm commitment to their strategy has favoured renewable energy infrastructure, particularly wind energy (Greeson, 2011). This has been reflected in the relative quantity and capacity of new renewable energy infrastructure build recently in the U.S. (Table 7.1).

Although coal continues to be the largest source of energy for electricity generation in the U.S., natural gas and renewable energy sources are leading in new capacity installations (U.S. Energy Information Administration, 2012) (Figure 7.8). Wind energy dominates the renewable energy market. However solar and biomass have an increasing market share (Figure 7.9). In contrast, hydropower capacity is forecast to remain relatively stable in the future leading to a decrease in its market share.

Although solar power plants are being built in high numbers, investors are favouring photovoltaic (PV) technology over concentrated solar power technology (CSP) for cost reasons (Konrad, 2011). Several projects that relied on funding from the Department of Energy (DOE) had to be cancelled or changed when the DOE terminated its loan guarantee program. Figure 7.10 shows the consequence of this event for CSP projects in 2011. Subsequently hybrid PV/CSP plants received more consideration as to lower costs while maintaining the energy storage benefits of CSP technology (Konrad, 2012). The future for CSP is not certain in the U.S. and is thought to be unsettled until at least

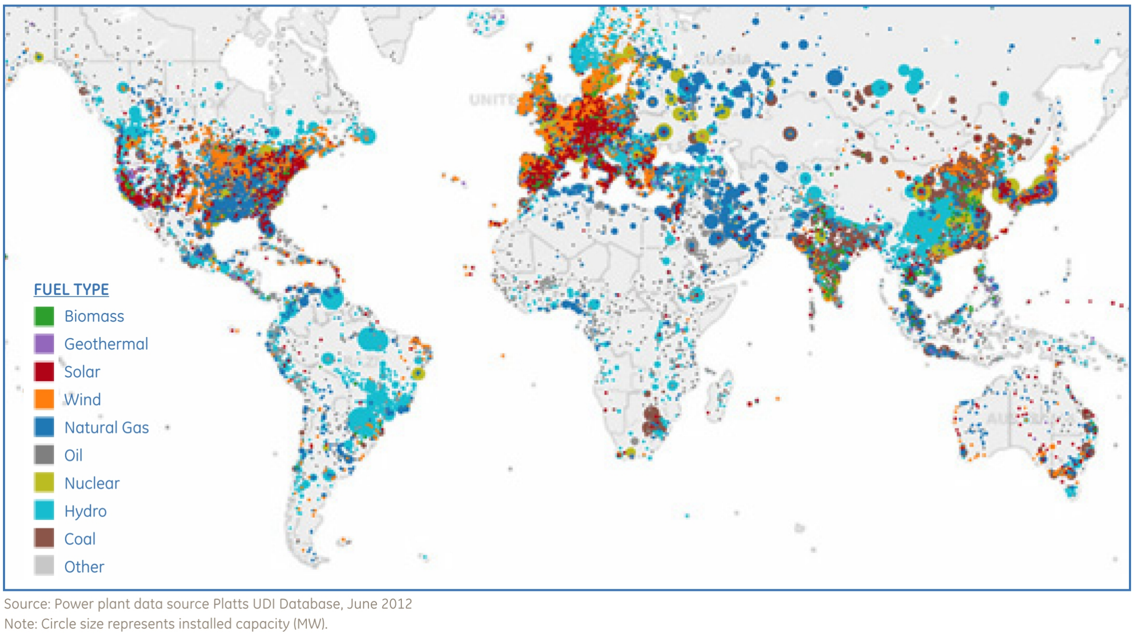


Figure 7.5. World power plants by technology. Circle size represents installed capacity in MW (*Source: Evans and Annunziata (2012)*)

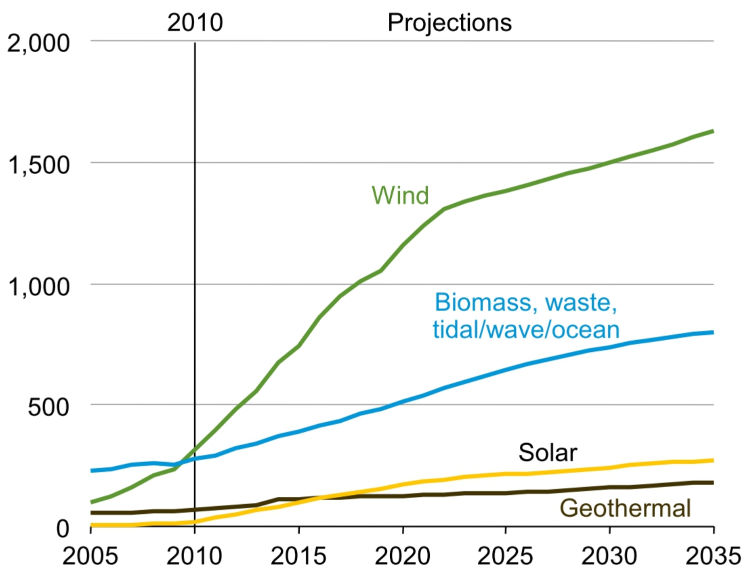


Figure 7.6. World renewable electricity generation by source, excluding hydropower, 2005-2035 (*Source: U.S. Energy Information Administration (2012), their Figure 70*)

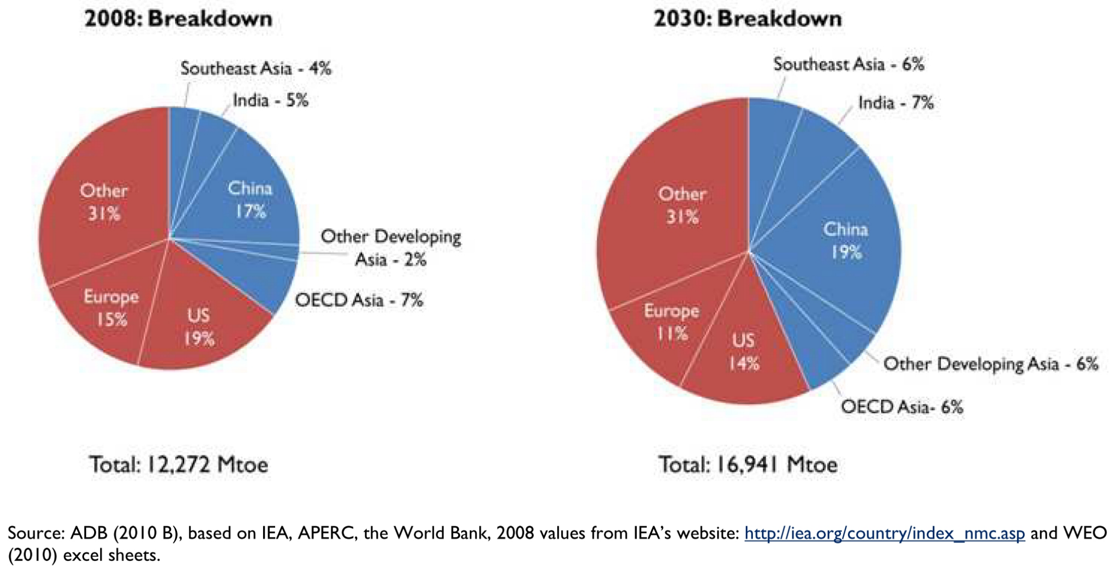


Figure 7.7. World electricity generation by region in 2008 with predictions for 2030 (*Source: du Pont (2011), their Figure 5*)

Table 7.1. New power generation infrastructure in the U.S. by technology type (*Data source: Federal Energy Regulatory Commission (2012, 2013a)*)

Primary Fuel Type	January – December 2011 Cumulative		January – December 2012 Cumulative		January – March 2013 Cumulative	
	No. of Units	Installed Capacity (MW)	No. of Units	Installed Capacity (MW)	No. of Units	Installed Capacity (MW)
Coal	15	1,932	8	4,510	0	0
Natural Gas	108	11,020	94	8,746	3	340
Nuclear	0	0	1	125	0	0
Oil	66	136	19	49	0	0
Water	41	94	13	99	4	5.4
Wind	146	6,844	164	10,689	6	958
Biomass	131	446	100	543	28	46
Geothermal Steam	9	56	13	149	0	0
Solar	354	1,131	240	1,476	38	537
Waste Heat	2	136	1	3	0	0
Other	11	0	5	0	0	0
Total	883	21,795	658	26,387	75	1,880

2020 (Navigant Research, 2011, 2012). This is not favourable for Sulzer Pumps since photovoltaic technology does not require pumps or other rotating machinery.

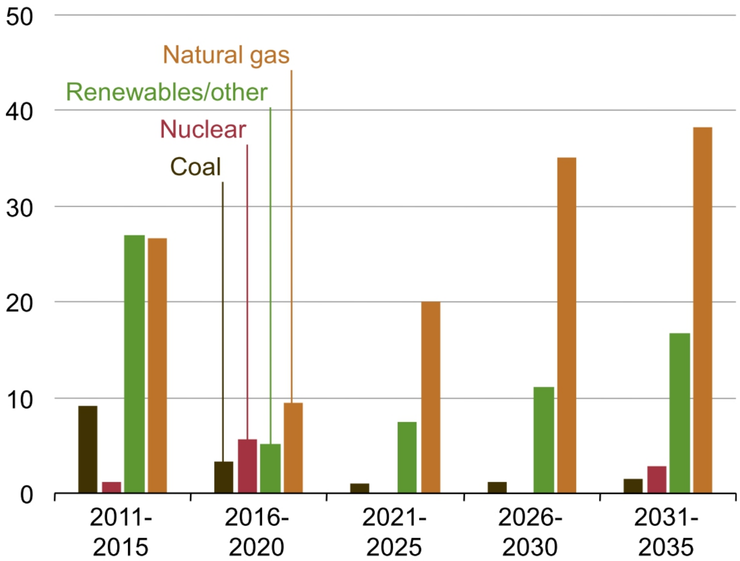


Figure 7.8. U.S. electricity generation capacity additions by fuel type, including combined heat and power, 2011-2035 (*Source: U.S. Energy Information Administration (2012), their Figure 95*)

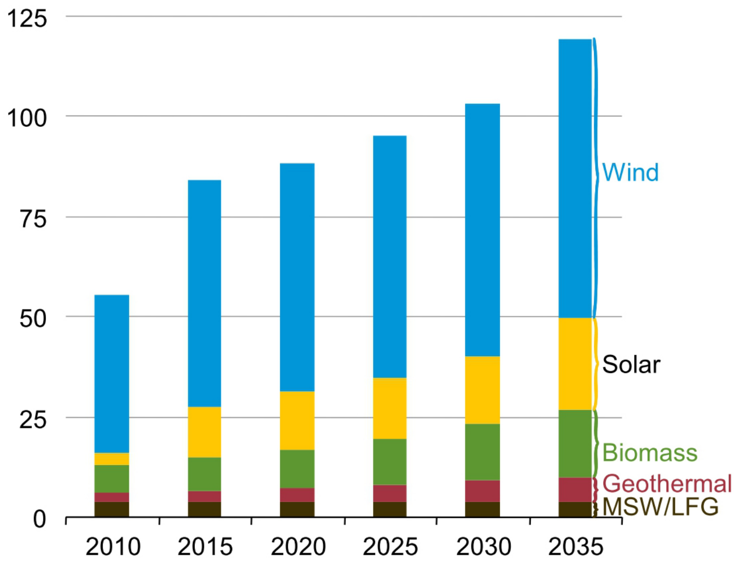


Figure 7.9. U.S. non-hydropower renewable electricity generation capacity forecast (*Source: U.S. Energy Information Administration (2012), their Figure 100*)

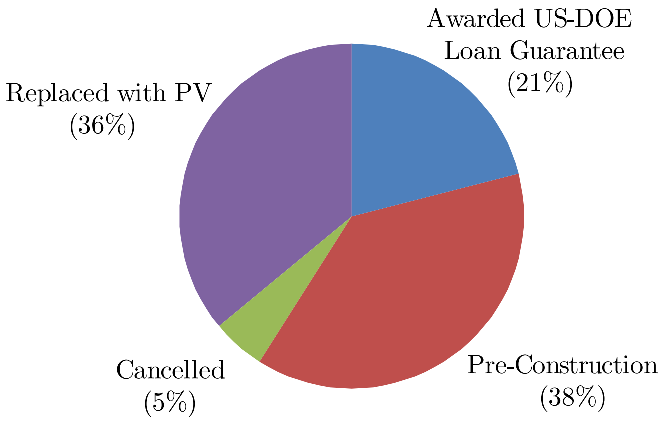


Figure 7.10. Concentrated solar project announcements in the U.S. (2011) (*Data source: David Hague and Asmus (2011)*)

European power generation trends and forecasts are similar to those in the U.S. due to a similar drive from industry regulations. The main regulatory driver in Europe is arguably the European Commissions 20-20-20 target to reduce emissions, increase energy efficiency, and increase the relative amount of energy produced from renewable resources (European Commission, 2013). This policy strong support for the use of renewable energy technologies is reflected in the European Unions power generation capacity statistics shown in Table 7.2.

Table 7.2. EU-27 electric power generation capacity 2000-2010 with predictions for 2020 (Source: Eurelectric (2011))

	2000	2008	2009	2010	2020
Nuclear	136,847	132,842	132,861	130,538	127,496
Fossil Fuel Fired	391,306	445,428	454,155	462,173	382,074
Hydro	135,626	141,694	142,905	142,726	160,974
Other Renewables	21,942	94,748	111,561	133,940	264,297
of which: Solar	82	10,102	15,244	22,981	55,735
Wind	12,808	64,034	74,614	83,819	177,809
Biomass	3,940	9,852	10,019	10,071	17,086
Biogas	975	3,799	3,092	3,891	5,795
Not Specified	440	1,198	1,143	1,144	1,162
Total Installed Capacity	686,161	815,910	842,624	870,521	936,004

In summary, fossil fuels remain the largest energy source in electrical power generation worldwide. However, the share of solid fossil fuel power plant capacity is declining. Instead, natural gas technology is expected to have the strongest capacity growth over the next two decades. Many renewable energy technologies are showing strong growth worldwide, with wind energy being clearly favored. Biomass and waste technologies show mild growth, while solar technology is still held back by its high costs. Hydropower is expected to have relatively little growth in the near future, just enough to maintain its current capacity share. Figure 7.11 shows an overview of the relative size and growth rate of current electricity generation technologies.

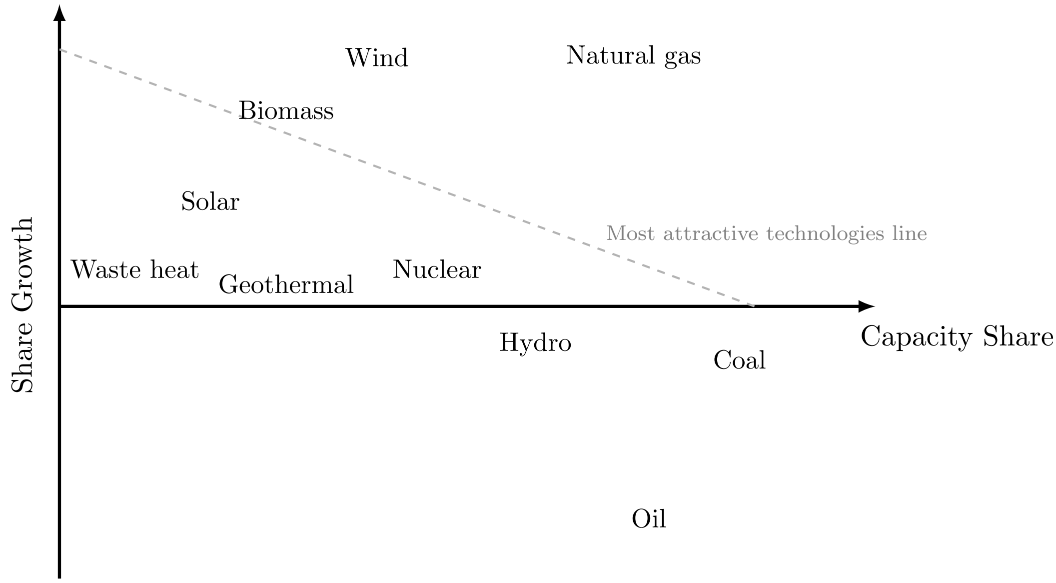


Figure 7.11. Capacity share versus share growth for electricity generation fuels (For visualisation only, not to scale)

Pumps in Power Generation

As mentioned in Section 7.2.1, thermal power plants demand the most pumps in the electricity generation segment. Within each thermal power plant many pumps are used for a variety of applications. However, some are more critical than others. Arguably the most important pumps are the large, high value, high energy pumps used in the water/steam cycle such as boiler feed water pumps, condensate pumps, and cooling water pumps (Tschanz, 2012). Figure 7.12 shows the total Sulzer install base for these types of pumps.

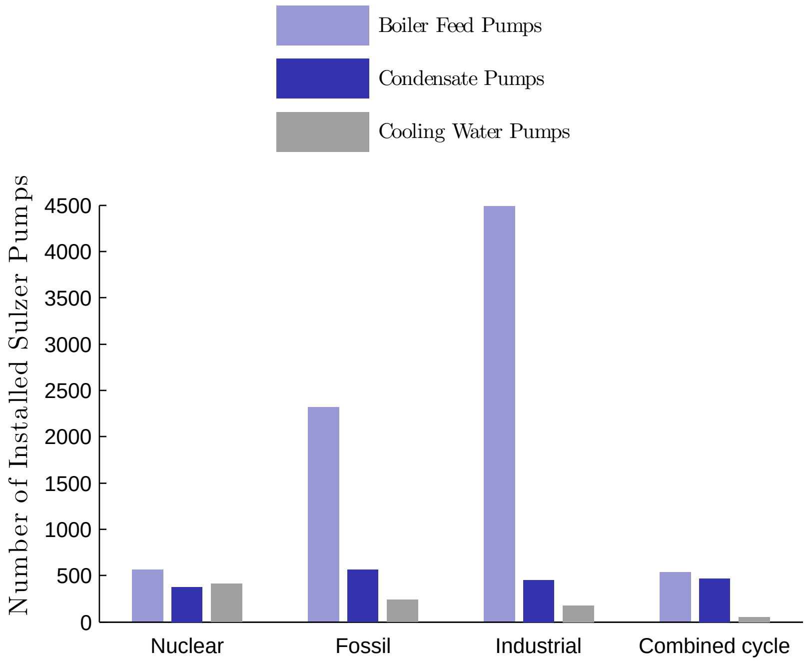


Figure 7.12. Installed primary system Sulzer pumps in power generation by power plant type. Data not currently available for other subsegments (*Source: Sulzer ERD*)

Although these pumps are critical to power generation in thermal power plants, they rarely cause outages in Europe. A survey of unavailability events by Eurelectric (2011) concluded that boiler feed water pump issues accounted for only 1.5 % of all unplanned downtime (see Figure 7.13). They later concluded that the heat generation process causes the majority of downtime (Eurelectric, 2012).

Assume that all the pumps represented in Figure 7.12 (10,650 pumps) are still in service and require monitoring. Also assume that the price of a monitoring system is €25,000 and monitoring systems are replaced every 12.5 years (i.e. replaced twice in the design life of the power plant, see Section 6.4.1). In this scenario the global market size for monitoring equipment, applied to critical Sulzer pumps within the power generation industry is €22m. Note that his estimate is similar to that made earlier in Section 6.4.1.

Other Rotating Machinery in Power Generation

Turbines and Engines

Legislation promoting highly efficient low carbon power production has prioritised renewable energy technologies and favoured combined cycle power plants for conventional fuels. Renewable energy electricity generation is now treated as a variable base load for the grid while conventional electricity generation plants provide top-up supply (Eurelectric, 2011). These newly formed roles demand better load following control over conventional power plants.

Considering this performance requirement, gas-fired power plants are arguably the best conventional fuel technology due to their short start-up times (Table 7.3), excellent load following ability, and compatibility with HRSG technology. Furthermore, the relatively low cost and short construction times of combined cycle gas and steam power plants adds to their attractiveness. For these reasons new infrastructure in the power generation segment is expected to be dominated by natural gas power plants (Figure 7.8), which may lead to a demand in gas turbine, steam turbine, and gas engine monitoring.

As shown in Section 6.4.1, there are approximately 1,800 combined cycle power plants worldwide, and the most common configuration comprises two gas turbines and one steam turbine. Hence, there are approximately 3,600 gas turbines and 1,800 steam turbines worldwide that may require monitoring.

Table 7.3. Approximate start-up times of various power plant types (*Sources: Eurelectric (2011) and Kehlhofer et al. (2009)*)

Power plant type	Start-up time	
Pumped storage	0.1 hr.	
Combined cycle gas and steam	40 – 170 min.	Note: Start-up times depending on plant size, standstill time and starting temperature
Hard coal	3 – 6 hr.	
Lignite (Brown coal)	6 – 10 hr.	
Nuclear	40 hr.	

Hydrokinetic Turbines

Ocean current turbine technology is still in its infancy. However, interest in this area of power generation is high due to the high amount of energy available for harvesting in ocean currents. Moreover, interest in condition monitoring is also high due to high cost of retrieving submerged ocean equipment (Beaujean, Khoshgoftaar, Sloan, Xiros, & Vendittis, 2010).

According to the U.S. Department of Energy (2013) there are very few (<5) commercial ocean energy devices deployed worldwide, therefore the market size for machine monitoring in this industry is insignificant at present. Although there are not likely to be immediate profitable machine monitoring business opportunities in this field, remote monitoring opportunities will almost certainly appear in the future due to the placement of ocean energy devices in remote and challenging environments. Hence tracking the needs of this industry may be of interest to Sulzer.

Electric Generators

Not all power plants require pumps or turbines to operate. However, every power plant requires at least one generator (with the exception of PV solar power plants). Generators have a broad variety of failure modes which can cause a significant amount of downtime (Figure 7.13). Moreover, according to Eurelectric (2011), generator faults cause more downtime than turbines and feed water pumps in thermal power plants. Figure 7.14 and Figure 7.15 show the distribution of different generator service issues.

On average air and liquid cooled generators require rewinding every 25 year while hydrogen cooled generators only require rewinding every 35 years (Lemberg & Tornroos, 2004). However, generators that are operated at high field currents or are stopped and restarted frequently are expected to have shorter life cycles (Zawoysky & Tornroos, 2001). For example, generators with a high start/stop frequency can expect insulation life to be approximately 30 % to 50 % of that in a generator operating continuously at its base load. This is most common in renewable energy where energy supply is inconsistent.

According to GL Garrad Hassen renewable energy consultants, generators have the highest failure rate of the wind turbine components (LeBlanc & Graves, 2011). The

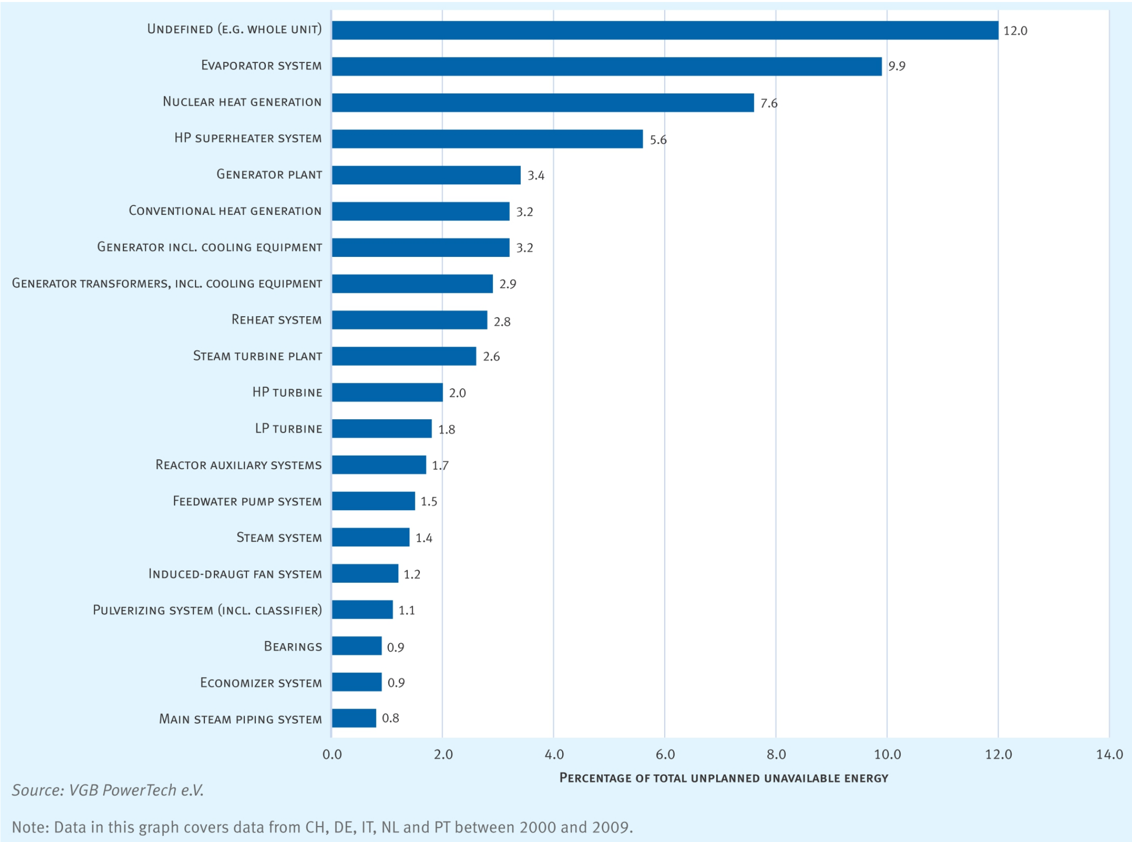


Figure 7.13. Cause of unplanned downtime for thermal power plants. Data from power plants in Switzerland, Germany, Italy, Netherlands, and Portugal (*Source: Eurelectric (2011), their Figure 11*)

National Renewable Energy Laboratory also specifies generators to be in the top three causes of wind turbine downtime along with gearboxes and electrical systems (Sheng, 2011). Current condition monitoring offers have a return on investment of less than three year leaving room for improvement.

Electric generator monitoring opportunities may exist for Sulzer. However, these opportunities would be rather suited to Sulzer Turbo Services (Dowding and Mills) generator repair business (Allen, 2011a) rather than business within Sulzer Pumps. Shelagh Tucker, works with Sulzer Turbo services and has extensive experience with generators. She states that the majority of generator monitoring services are performed with the generator offline because many tests require the generator to be reconfigured or dismantled. Hence, the potential for advanced online condition monitoring of generators may be limited.

Global wind energy production is growing strongly with the total installed capacity having a growth rate of approximately 19 % over the last two years. In 2011, 23,640 wind turbines capable of producing 41 GW brought the world total installed capacity up to approximately 240 GW (199,064 turbines) (Global Wind Energy Council, 2013). Moreover, the development of offshore wind technologies has led the installed offshore capacity to grow 31 % from 2011 to 2012. Small wind turbines (< 100 kW) represent approximately 20 % of the world capacity wind energy capacity with a total of 730,000 units installed by the end of 2011 and a growth rate of 11 % (Maeda & Pirazzi, 2013). The vast majority of small wind turbines (approximately 500,000) are installed in China.

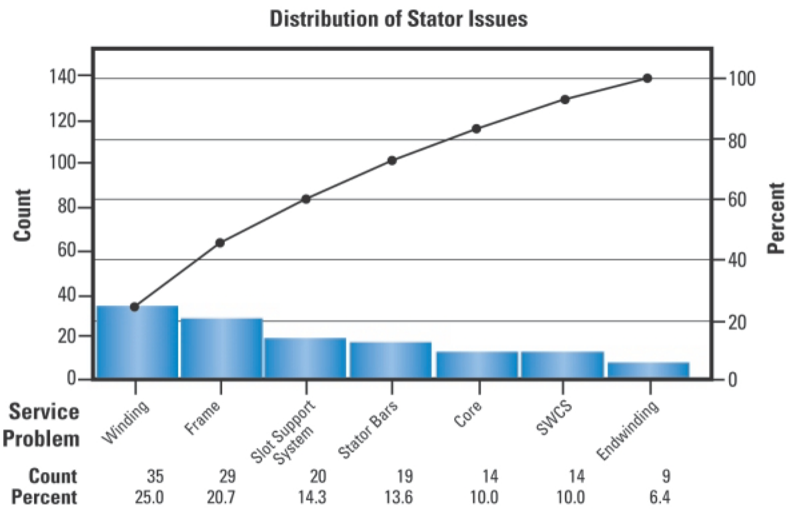


Figure 7.14. Distribution of service issues with generator stators in wind turbines (*Source: Lemberg and Tornroos (2004), their Figure 8*)

Generator Condition Monitor from Croatian company Mikrotrend is a generator specific solution that monitors both electrical and mechanical components (Mikrotrend Company, 2013). Furthermore, unlike StatorMonitor, rotating generator components are also monitored via wireless data acquisition. Hence, Mikrotrend may be worth considering for acquisition to complement Dowding and Mills StatorMonitor technology. General Electric offer condition monitoring for generators in hydroelectric power plants by supplying a range of specific modules and sensors for use wit their BN3500 rack (Rasmussen & Howard, 2004). They also offer a system for monitoring electric motors known as Motor Stator Insulation Monitor (MSIM). These solutions are compatible with GE's System 1 software.

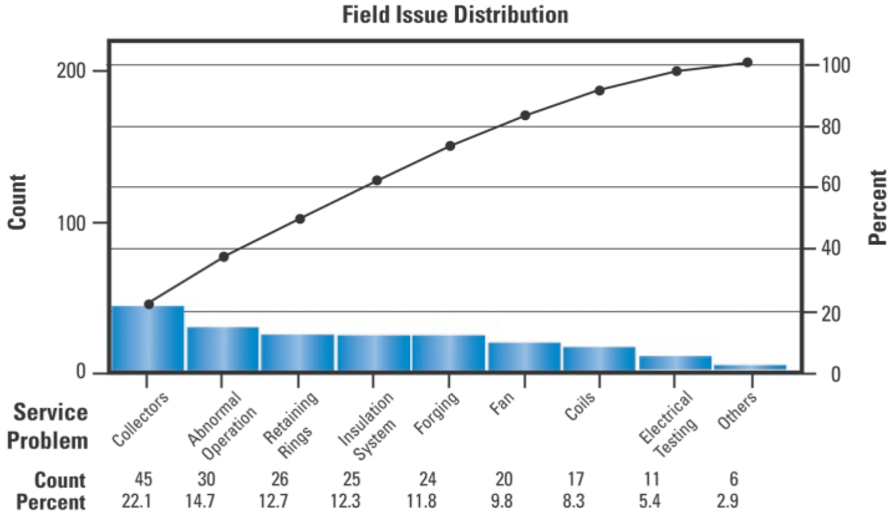


Figure 7.15. Distribution of service issues with generator rotors (field components) in wind turbines (*Source: Lemberg and Tornroos (2004), their Figure 9*)

7.2.2 District Heating

District heating refers to the distribution of centrally produced heat over considerable distances to be used for remote heating. Heat sources for a district heating system are often cogeneration power plants, also known as combined heat and power (CHP) plants. These types of power plants are becoming increasingly popular as they utilise heat produced that is not suitable for electricity generation, and hence have a superior efficiency over conventional power plants (Figure 7.16). For example, Unit 9 of Grosskraftwerk Mannheim (GKM) power plant (to be commissioned this year, 2013) is expected to have an electrical efficiency of just 46.4 %. However, utilising CHP processes it is expected to utilise up to 70 % of its input fuel.

In 2004 the European Parliament recognised the European Unions rising dependency on external energy supplies and created directive 2004/8/EC (European Commission, 2004) (as an amendment to directive 92/42/EEC) to promote the use of cogeneration geared towards making energy savings. Cogeneration and district heating are also supported by initiatives to lower emissions (UK Department of Energy and Climate Change,

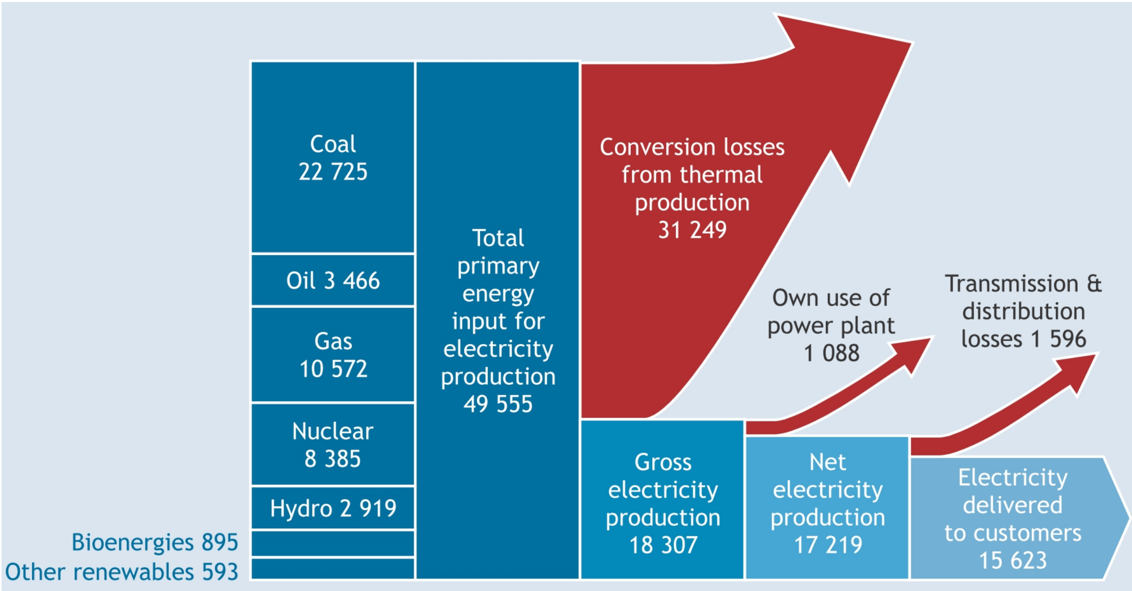


Figure 7.16. Energy flows in the global energy system (TW h) (*Source: International Energy Agency (2008), their Figure 3*)

2013). In fact, district heating plants have been claimed to be on average at least twice as clean as conventional heating plants (Euroheat & Power, 2007). Promotion of district heating consequently benefits Sulzer Pumps since it requires pumps to move the working fluid (most commonly water) in order to distribute heat.

There are three elements to a district heating system: generation, transmission and distribution, and user solutions (Figure 7.17). Generation involves creating heat and transferring it to the working fluid. The heat must then be distributed to the end users. This is usually done by pumping fluid from the heat source to a distribution station, and then from there distributing heat to the end users. Finally, end users require solutions to use the provided heat supply. Sulzer Pumps would arguably be suited to business in the distribution stage of district heating since this stage is the most pumping intensive.

Monitoring Opportunities in District Heat Distribution

Both reliability and optimisation opportunities may exist in district heating systems. Firstly, reliability issues include maintenance of the distribution pumps and pipe network. For example, some countries that established district heating systems early now have

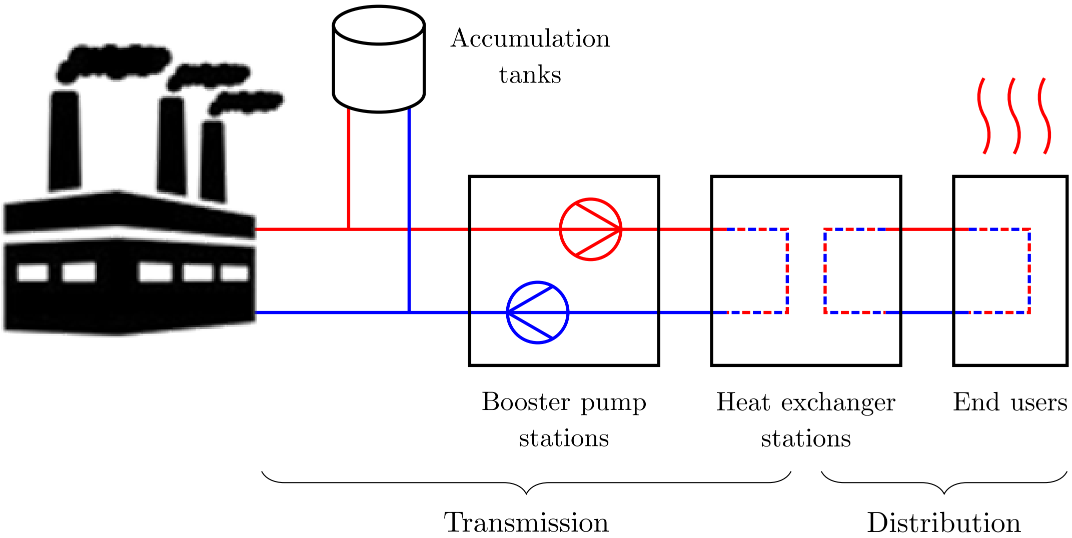


Figure 7.17. District heating distribution level diagram

problems with leaks from corroded pipes. It is estimated that some Swedish companies lose several million cubic meters of water every year due to leaking pipes (FLIR Systems, 2013). Hence, leak detection in district heating systems is of upmost importance to protect the environment and to minimise financial losses. Currently, new infrastructure projects in London, UK, are specifying leak detection (Greater London Authority, 2013) to meet the standard BS EN 14419 (BSI Group, 2009). Secondly, as with any fluid distribution network, energy losses can be large in both pumps and pipes. Optimisation of district heating systems may hold significant energy cost savings for customers.

District Heating Monitoring Market Size Estimate

Denmark has used district heating since 1903 when the first Danish CHP and waste incineration plant was build. Since then Denmark has been recognised as a world leader in district heating. Figure 7.18 shows how the promotion of CHP plants have decentralised power production in Demark since 1985 to increase the countries energy efficiency. Now over 60 % of the Danish population is served by the nation's district heating networks. Moreover, current research still supports the expansion of district heating networks to further increase energy efficiency (Sperling & Möller, 2012).

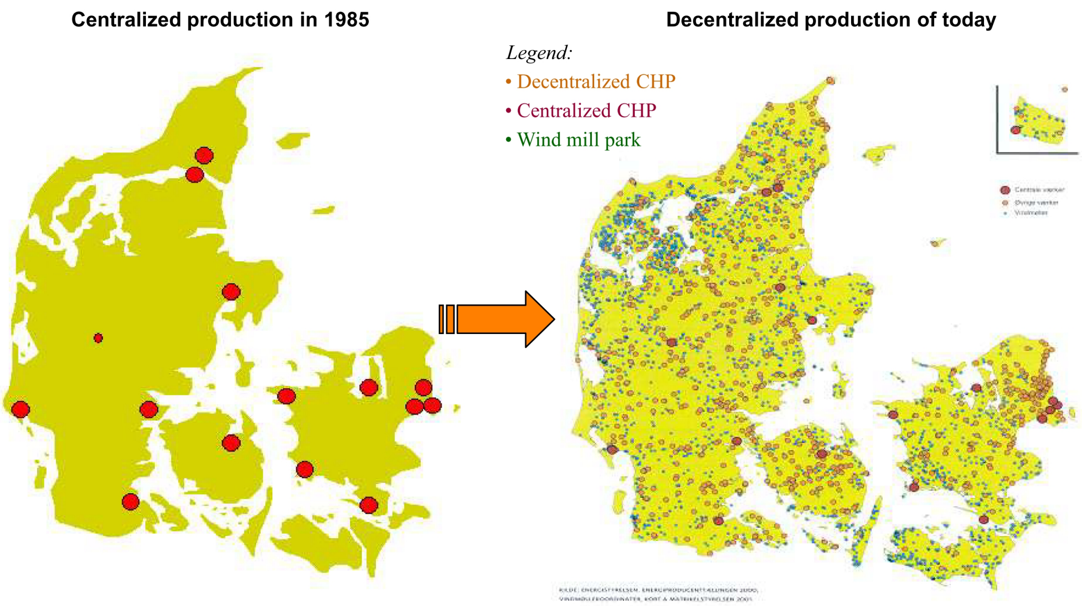


Figure 7.18. Adoption of CHP plants in Denmark (*Source: (Christensen, 2009)*)

Figure 7.19 shows the amount of district heating infrastructure installed in various other countries. Approximately 57 % of the European Union population live in regions having at least one district heating network. Heat delivery in the EU-27 countries is expected to grow by a factor 2.1 until 2030, and then a factor of 3.3 until 2050 (Connolly et al., 2012). Application of district heating in China grew rapidly between 1980 and 2003 with the number of cities using the technology increasing from 10 to 32 (Lieyuan, 2009). China is still expanding its district heating networks in order to reduce its carbon emissions and tackle poverty. For example, the Urumqi District Heating Project began in 2011 (US$343m (The World Bank, 2011), 54 km of heating pipeline (Xinjian Environmental Technology Consulting Center, 2011)), and the Heilongjiang Energy Efficient District Heating Project (US$353m, 217 km of heating pipeline) has recently received funding from the Asian Development Bank (2013a, 2013b) and is due to commence in 2013.

Taking the Copenhagen district heating system as an example an estimate for the global district heating maintenance market size can be calculated. The two largest heat distribution networks organisations supply heat to the central (CTR - Centralkommunernes Transmissionsselskab) and western (VEKS - Vestegnens Kraftvarmeselskab) districts (Figure 7.20). The central network has approximately 54 km of transmission pipe with 3

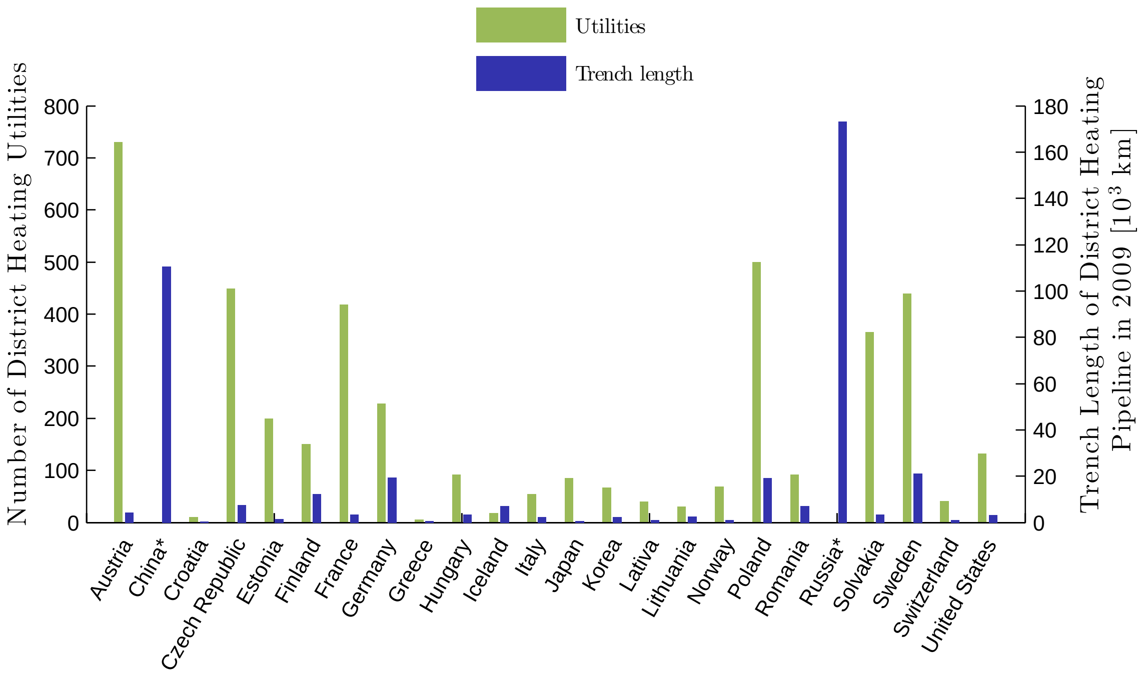


Figure 7.19. Number of district heating utilities and the trench length of pipelines in various countries (*Data source: Power (2009)*)

pump stations and 26 heat exchanger stations (The Metropolitan Copenhagen Heating Transmission Company, 2004), while the western network has approximately 105 km of transmission pipe with 7 pump stations and 44 heat exchanger stations (Eigaard, 2006). In the CTR network, it is normal for each pumping station and heat exchanger station to contain three 50 % pumps to circulate the hot water (Elleriis, 2002). Combining the two Copenhagen networks the aforementioned figures yield an average transmission pipe length of approximately 2 km per pump.

The total length of district heating transmission pipe for the countries listed in Figure 7.19 is 409,000 km. Assuming that the districting heating networks in these countries are constructed with similar specifications to those in Copenhagen, this would mean that there are approximately 200,000 district heating pumps that may require monitoring worldwide. Not that this estimate is likely to be conservative since Figure 7.19 does not contain all countries using district heating, and the figures used for calculations were from 2009 statistics. Assuming that each pump requires a monitoring system worth \$10,000 that

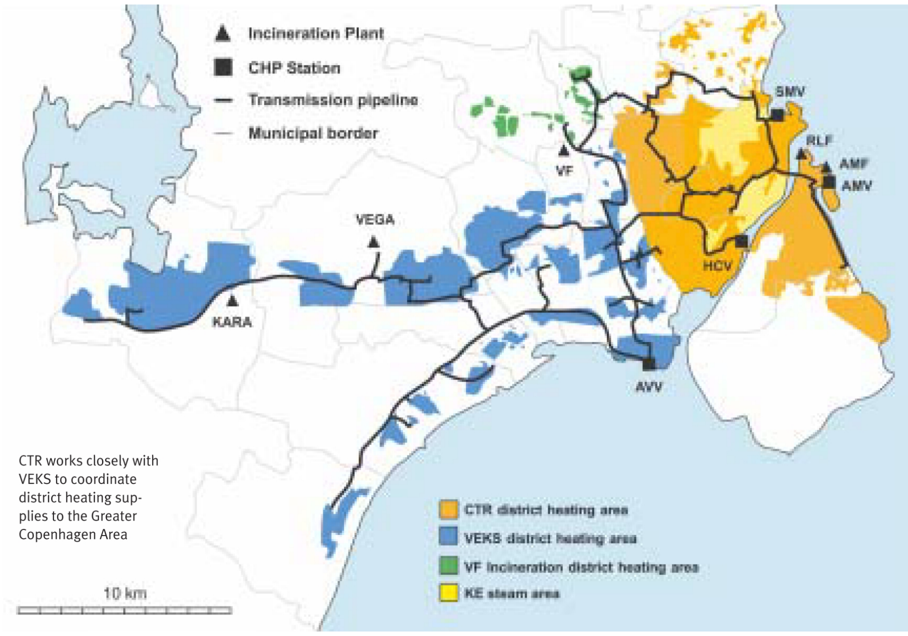


Figure 7.20. District heating networks in Copenhagen, Denmark (*Source: (The Metropolitan Copenhagen Heating Transmission Company, 2004)*)

will be upgraded every 10 years, the market size for pump monitoring equipment in the district heating segment would be $200m.

Alternatively the market size can be estimated with the VEKS annual heat transmission network maintenance costs data shown in Figure 7.21. Assuming a design life of 30 years, the average maintenance cost per year over the 30 years is approximately €1500 per kilometre of pipe. Again, using the total pipe length of the district heating networks within the countries listed in Figure 7.19, the global district heating network maintenance market size would be €614m. The monitoring market for pumps will only be some portion of this broader market.

Competitor Solutions in District Heating Control and Monitoring

FLIR Systems have used thermal imaging cameras attached to small aeroplanes to detect leaks in district heating pipe networks while flying over cities (Figure 7.22). Stockton Infrared Thermographic Services also provides a similar service (Stockton, 2013). KSB has supplied variable speed drive controllers for pumps in district heating systems in Eastern Europe. The implemented intelligent pump control to supply heat 'on demand'

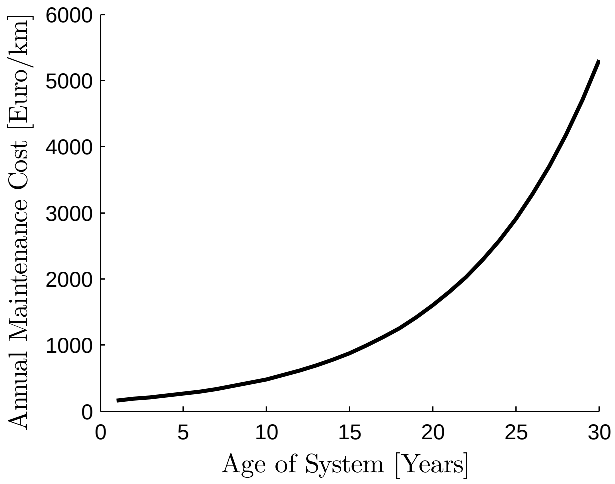


Figure 7.21. Annual maintenance costs for the VEKS heat transmission network as a function of system age (*Source: Kamp (2002), data from the year 2002*)

is claimed to save 20 % to 30 % of heat losses (KSB Aktiengesellschaft, 2010). Similarly, ABB has also provided modern electric motors with controllers to replace old equipment and improve the energy efficiency of CHP plants in Sweden (ABB Company, 2009).

Figure 7.22. FLIR Systems has used thermal imaging to detect pipe leaks in district heating systems. (*Source: FLIR Systems (2013)*)

7.2.3 Customer Segments in Power Generation

To sell a predictive maintenance program, Mobley (2002) suggests that the program must convince at least the following five levels of management with an organisation:

1. Corporate management
2. Plant management

3. Division management
4. Line Supervision
5. the hourly workforce

Each of these groups, or customer segments, must see benefits in the predictive maintenance program to reduce resistance to purchasing it. For power generation and water utility projects, the number of customer segments is extended further due to multiple organisations having interests or responsibilities in these projects (Figure 7.23). Furthermore, both EPC, and operations and maintenance (O&M) organisations are likely to be involved in such projects, and may have very different priorities and interests in machine monitoring (see Figure 5.8).

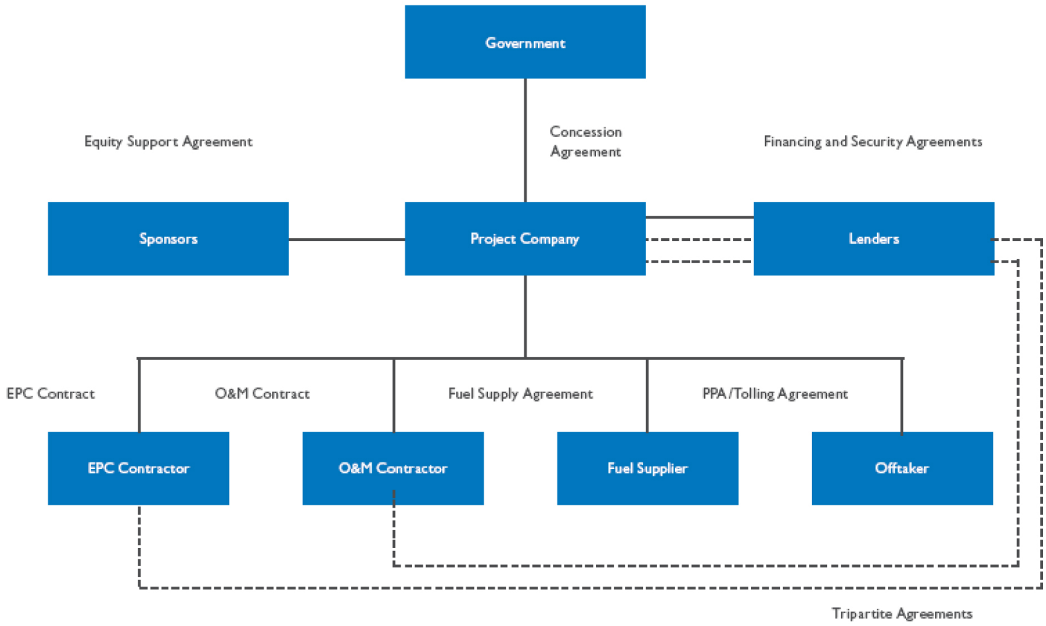


Figure 7.23. Basic contractual structure of a project-financed power project using an EPC contract (*Source: DLA Piper (2011)*)

7.3 Segments of the Water Industry

The value chain of the water industry can be divided into three main areas: supply, use, and sanitation and drainage (Figure 7.24). Sulzer Pumps focuses its business within the supply and sanitation subsegments, but is also involved in providing water pumps to general industry, i.e. the water use subsegment. Value chains within both the supply and sanitation subsegments heavily rely on pumps and contain many machine monitoring opportunities. Investigations into trends and opportunities within each of these two subsegments are presented in Section 7.3.1 and Section 7.3.2 respectively.

7.3.1 Water Supply

Figure 7.25 shows that the water supply value chain contains many steps. However, the main stages of supply are intake (or withdrawal), transport, treatment, and storage and distribution. Although the water treatment steps make up a significant portion of the value chain, Figure 7.26 shows that investment in this market is relatively small.

Water Intake and Treatment

Water production is considered very energy intensive as energy costs often account for approximately one third of the total operation and maintenance expenses of a typical water production plant (Ram, 2012; Sensus International, 2012) (Figure 7.27). Clean water production via a desalination process is even more energy intensive, as about 55 % of the total operating and maintenance expenses go towards energy costs (Figure 7.28). Hence reducing the specific energy required to treat water is in the interests of most water utilities.

Reverse osmosis in the dominant technology (about 60 % of desalination plants) and multi-stage flash technology is second most common (Figure 7.29). To reduce emissions associated with energy used to operate desalination plants, modern plant are incorporating renewable energy technologies (International Desalination Association, 2013b). In particular, concentrated solar power (CSP) technology is expected to become a major technology for electricity production in combination with desalination as regions with high solar power potential typically also have relatively high water scarcity (Trieb, Moser, & Fichter, 2011). The Middle East and North Africa are examples of such regions (International Energy Agency & International Renewable Energy Agency, 2012).

Development and acceptance of desalination technologies combined with a strong de-

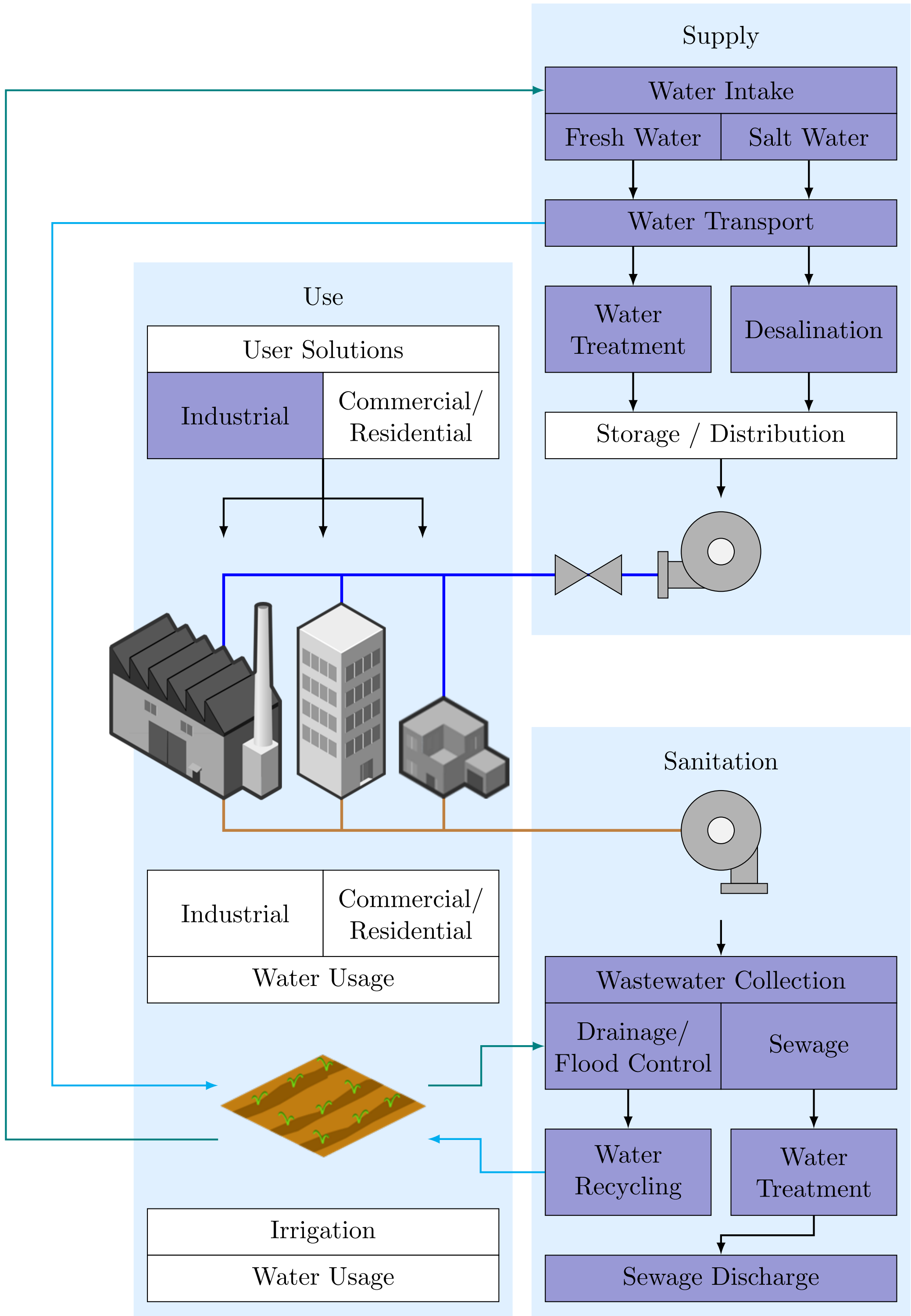


Figure 7.24. The value chain for the water market (Sulzer is currently involved in processes marked in blue)

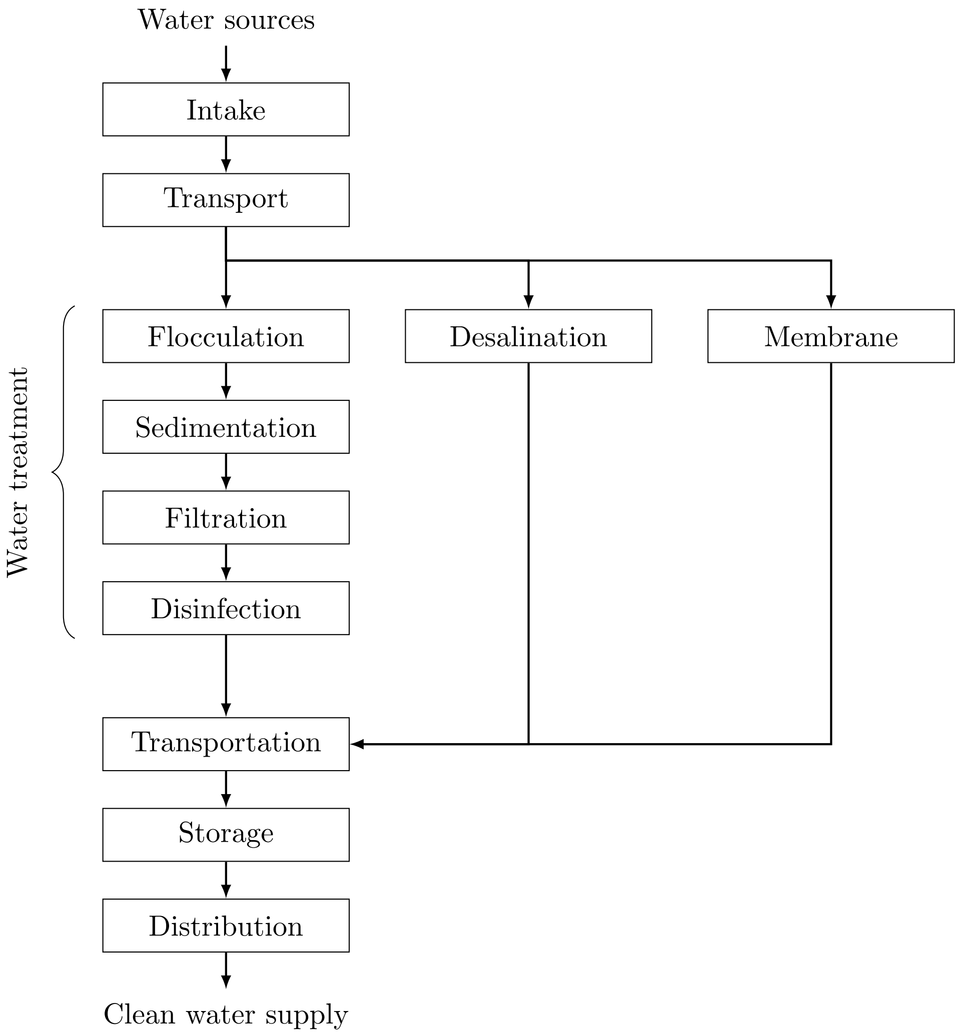


Figure 7.25. The water supply industry value chain

mand for water due to the expanding world population has lead to high growth in the desalination market. Between 2001 and 2011 the world desalination capacity grew by 276 % (Craze, 2013), and now there are approximately 16,000 desalination plants spread throughout 150 countries (International Desalination Association, 2013a). From 2010 to 2016 the desalination market is expected to grow by 9 % annually, with 54 % of global growth expected to occur in the Middle East and North Africa regions (International Energy Agency & International Renewable Energy Agency, 2012).

As membrane feed pumps are at the heart of the reverse osmosis desalination process

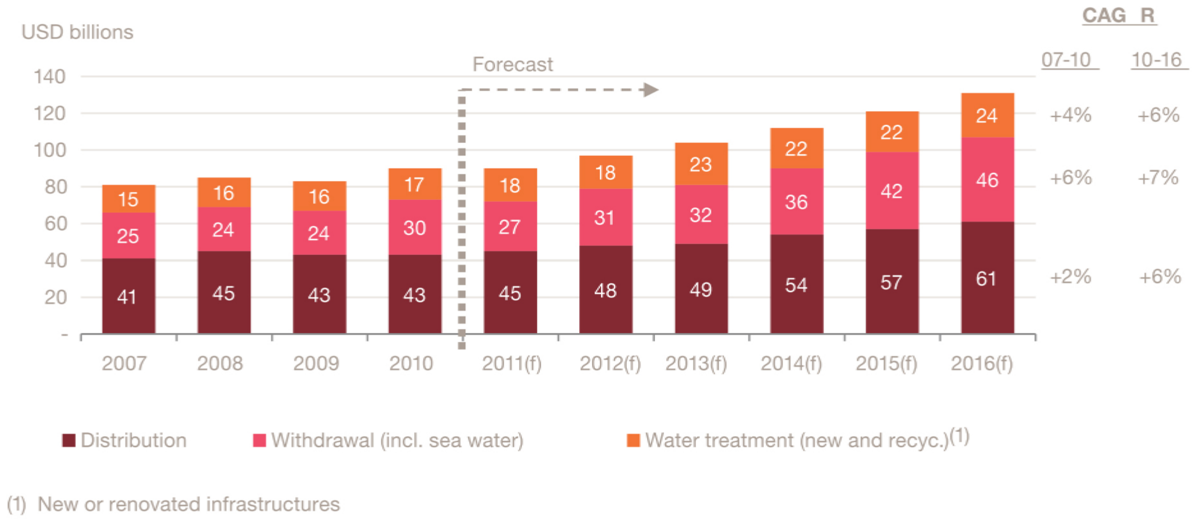


Figure 7.26. Investment in water supply infrastructures forecast (*Source: Leclerc et al. (2012), their Figure 17*)

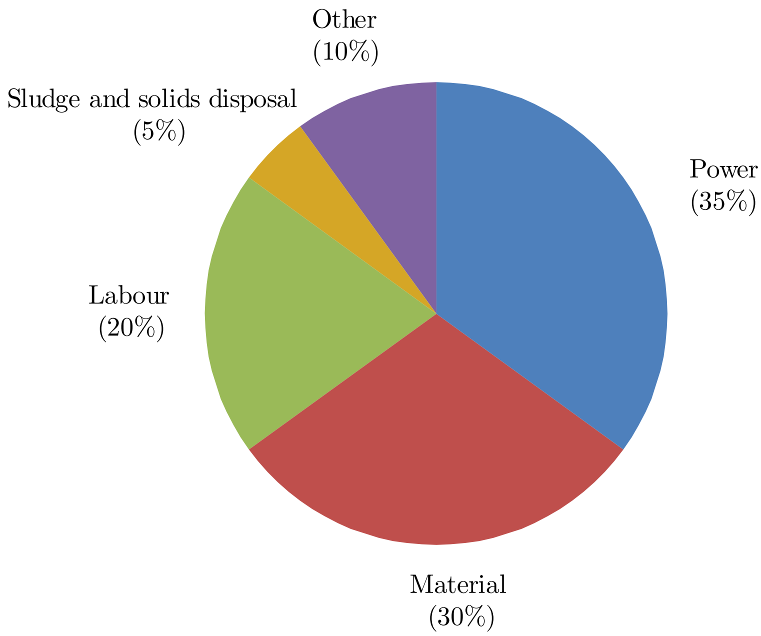


Figure 7.27. Typical breakdown of water production operation and maintenance costs for a water utility (*Data source: Sensus International (2012)*)

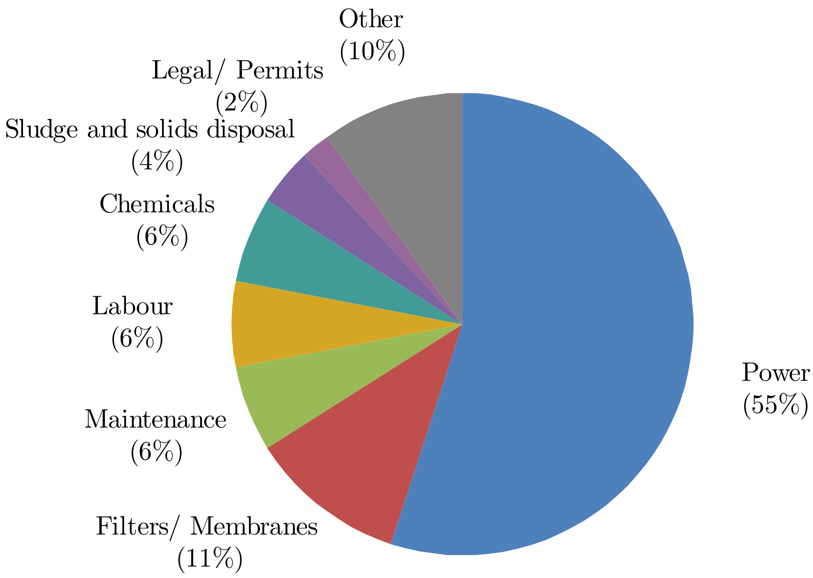


Figure 7.28. Typical breakdown of operation and maintenance costs for a desalination plant (*Data source: WateReuse Association (2012)*)

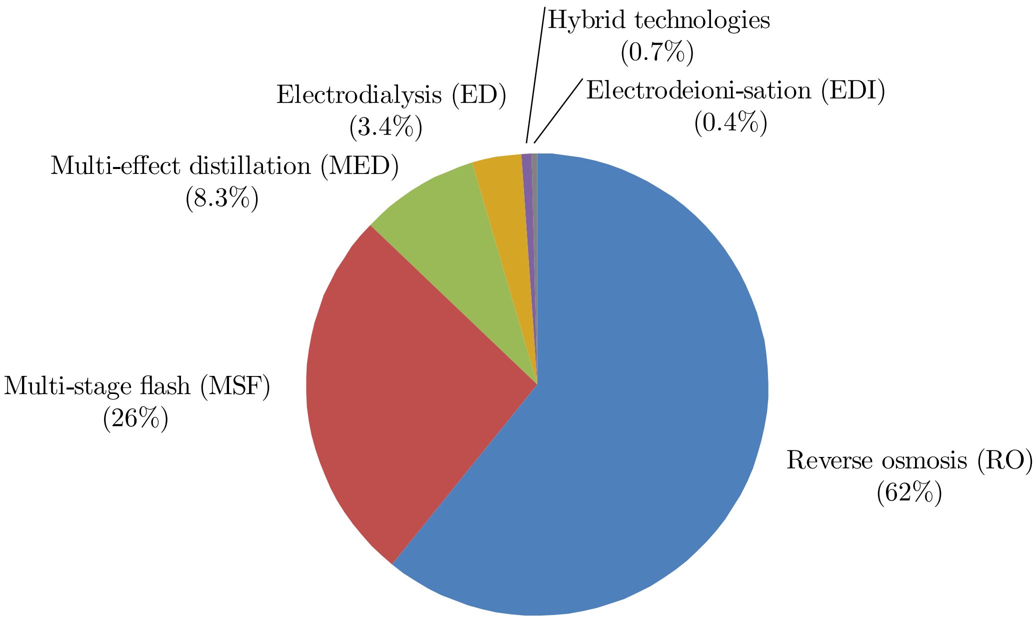


Figure 7.29. Desalination technology usage (*Data source: International Desalination Association (2013b)*)

and must work under harsh environment of seawater, customers in this industry may have interests in pump monitoring to ensure that their pumps are operated reliably and efficiently. However, the strength of their interest is not known. Competitor attitudes to condition monitoring in this market vary with KSB stating that their HGM-RO pump does not require monitoring (KSB Aktiengesellschaft, 2012), while the ITT Goulds 3393 reverse osmosis pump comes with the ITT Goulds i-Alert condition monitoring unit onboard as standard (ITT Corporation, 2011).

Water Transport

Water pipelines are often used to transport source water from its place of origin to treatment plants or agricultural regions, and also from treatment plants to areas lacking reliable water supply. However, the water pipeline industry is relatively small compared to the oil and gas pipeline industry since ground or surface water is available in many locations while oil and gas wells are often more remote. Moreover, water may be transported by other means such as open aqueducts or canals which are not suitable for transporting oil and gas due to practical, safety and environmental reasons.

Requirements of customers in the water pipeline industry are typically less demanding than those of customers in the oil and gas pipeline industries since water transport has relatively few environmental and safety concerns. However, water pipeline efficiency still benefits from monitoring solutions such leak as detection and energy monitoring. Refer to Section 7.4.4 for oil and gas pipeline monitoring solutions.

Water Distribution

Similar to the district heating industry, the main monitoring opportunities in the clean water distribution industry are in leak detection and network optimisation. Pipe leak detection is important to operate water distribution networks efficiently, but is not as important as leak detection in the district heating industry since clean water networks are not closed systems. Pipe networks are usually maintained through preventative maintenance programs since the complexity and open nature of water distribution networks makes unwanted leak detection difficult.

Optimisation of water distribution networks through advanced control and monitoring solutions can present significant cost savings to water utilities. For example, advanced pump control that reduces the overall system pressure can result in savings in the energy required to pressurise the network, pipe maintenance costs (since pipes are less stressed), leakage losses, and equipment repairs. Moreover, these costs form the majority of a water utilities distribution operation and maintenance expenses (Figure 7.30). However, customers interested in network optimisation realise that pump monitoring is merely a partial solution and expect full solutions to also consider other network infrastructure.

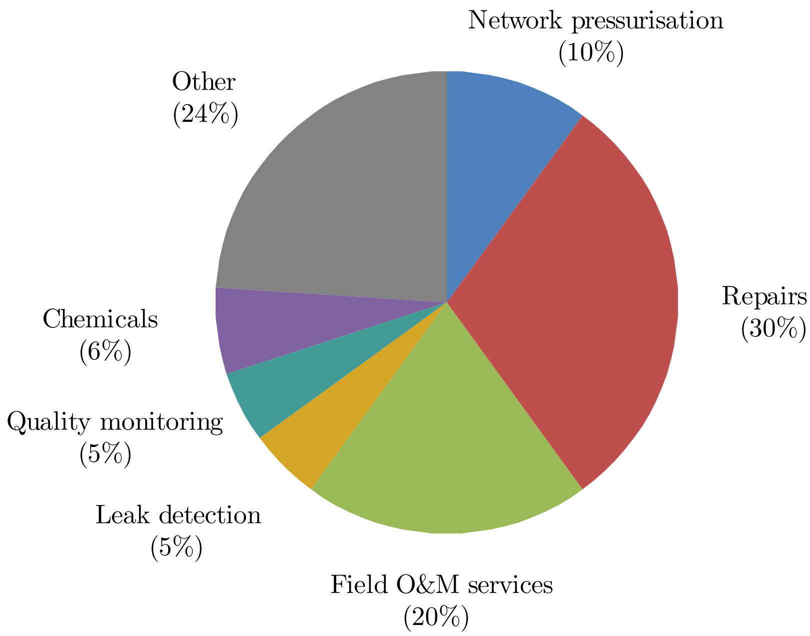


Figure 7.30. Typical breakdown of water distribution network operation and maintenance costs for a water utility (*Data source: Sensus International (2012)*)

The balance between maintenance and new equipment expenditure can vary greatly between countries. For example, Figure 7.31 shows that 82 % and 18 % of water distribution investment in Germany is spent on maintenance and new equipment respectively, while investment allocation in Brazil is almost the exact opposite. This should be taken into account in future business models by recognising the needs of both maintenance focused, and new equipment focused customer segments.

As with condition monitoring solutions, adoption of smart water network control so-

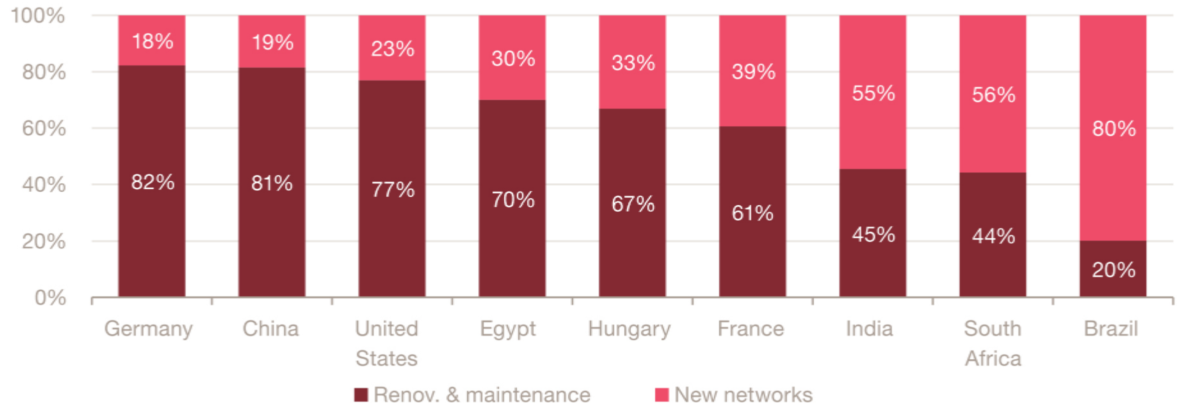


Figure 7.31. Investment in water distribution in various countries (*Source: Leclerc et al. (2012), their Figure 31*)

lutions in industry is very slow, even though the conceptual benefits of these solutions are high. A survey of water utilities by Sensus International (2012) revealed that this is due to weak businesses cases, as 65 % of participants agreed that current business cases failed to be compelling. The top three reasons for this outlook were all based on the view that the benefits of smart water networks did not yet justify the cost investment. Other reasons included a lack of political support, and a lack of user-friendly technology integrated into solutions.

Grundfos are currently marketing their water distribution solutions under the title of 'demand driven distribution' (Grundfos, 2013). Similarly, KSB is offering demand-driven operation solutions under their BOA product range (KSB Aktiengesellschaft, 2013). These control products aim at managing water distribution network pressure in order to save energy and maintenance costs. Schneider Electric currently offer a water network management software package called Aquis which can be integrated with SCADA systems to record, display, and forecast network operation states. Aquis has several modules for network optimisation including a leak detection, pump and reservoir optimisation, production optimisation, and pressure optimisation. IBM offers similar solutions such as IBM Maximo Asset Management (IBM, 2012) and IBM Intelligent Water (IBM, 2011) software. Takadu also offers software solutions that analyse data from SCADA systems and alerts operators to abnormalities (Takadu Ltd, 2012). In 2011 GE Intelligent Platforms began collaborating with Suez Environment to develop solutions for water network optimisation (GE Intelligent Platforms, 2011). However, there is no indication of a product release from these two companies at present.

7.3.2 Wastewater

Wastewater (or sanitation) is the second major segment of the water market where Sulzer Pumps currently offers solutions (Figure 7.24). A more detailed value chain for the wastewater market segment (Figure 7.32) shows that there are two major subsegments within the wastewater market; 1) wastewater collection and 2) waste water treatment. Trends and demands within these two subsegments are presented in Sections 7.3.2 and 7.3.2 respectively.

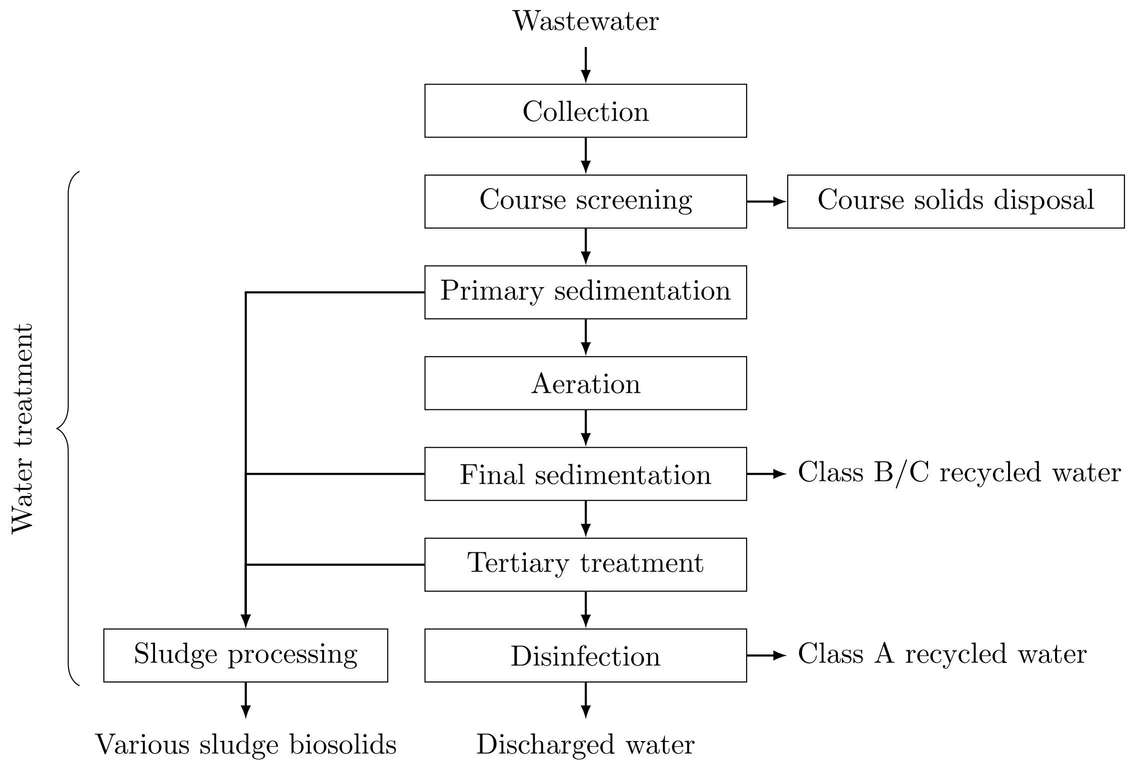


Figure 7.32. The wastewater industry value chain

Wastewater Collection

Unlike clean water distribution there is no need for a pressurised network in wastewater collection, just the transfer of sewage between open sumps or reservoirs. However, the properties of wastewater present handling issues that are nonexistent in the clean water segment. Hence, control and monitoring requirements for wastewater collection are significantly different from those in clean water distribution.

Maintaining collection system functionality is the primary objective in the wastewater collection segment, as accidental discharges of sewage can lead to wastewater network operators receiving hefty fines (see Section 6.5.2). Minimising energy and maintenance costs are secondary objectives. Currently Sulzer offers a range of pump intelligent control products to optimise wastewater pump operation. However, ABS has a relatively small market share in this market.

Several other pump and electronic equipment manufacturers offer competing pump control solutions for customers in the wastewater industry. For example, Schneider Electric offer pump controllers that are specifically designed for applications in the storm water and wastewater transport industries, for independent operation or operation under a centralised control system (Schneider Electric, 2013b). Grundfos also offer controllers specifically designed for wastewater transport applications (Grundfos Company, 2010).

Wastewater Treatment

Energy efficiency appears to be the main focus of the waste water market at present. Since approximately one third of waste water treatment plant operation costs are used to fund energy (Ram, 2012), energy cost savings can significantly reduce overall plant operation costs. In fact, recently a wastewater treatment plant in the U.S. changed their lighting from high-pressure sodium (HPS) and mercury vapour (MV) fixtures to LED fixtures to save electricity costs (Sustainable Plant, 2013).

Unfortunately, pump stations for transferring waste water only account for a relatively small amount of the plant total energy consumption. The most energy intensive process in wastewater treatment is aeration, a mechanical treatment which accounts for about 60 % of energy consumed (Ram, 2012). Sulzer has already successfully delivered energy saving solutions to customers in the wastewater industry and uses case studies to promote their offerings (Janssen & Albercht, 2011; Sulzer Ltd, 2012a, 2012b). Competitors for energy management in the wastewater treatment segment include most of those from the water treatment and distribution segments (see Sections 7.3.1 and 7.3.1) since the requirements in those segments are similar. Schneider Electric offer a range of energy management solutions specifically designed for waste water treatment plants (Schneider Electric, 2013a).

Current research aims to go beyond managing input energy for wastewater treatment plants, and aims at making treatment plants self sufficient or even have net energy outputs. This is possible by using biogas produced during nutrient removal processes to fuel a CHP plant (Wett, Buchauer, & Fimml, 2007). The deammonification process, or DEMON process (patented by the University of Innsbruck, Austria (Cyklar-stulz Abwassertechnik GmbH, 2010)), for nitrogen removal has been shown to be well suited for this application. Introduction of such energy focused technology is slow due to the organisational structure of municipal wastewater treatment plants. For example, the primary responsibility of treatment plant operators is to ensure that the plant is operating correctly. Meanwhile, energy costs of the plant are usually outside of their scope of responsibility (Scott, 2012).

7.3.3 Competitors in the Water Market

Sulzer Pumps main competitors in the water machine monitoring market are arguably large firms such as ITT, Flowserve, and KSB that already offer solutions to both clear water and wastewater subsegments. These companies hold significant market shares in the water pumps market and also have competing machine monitoring offers. Companies such as Xylem (part of ITT Group) are particularly strong since they offer significantly broader product ranges that Sulzer in the water industry (e.g. water monitoring, environment monitoring, heat transfer products, etc), and therefore provide customers with the convenience of a 'one-stop-shop'. In order to compete with such companies, Sulzer must provide a distinctively competitive solution via a superior business model.

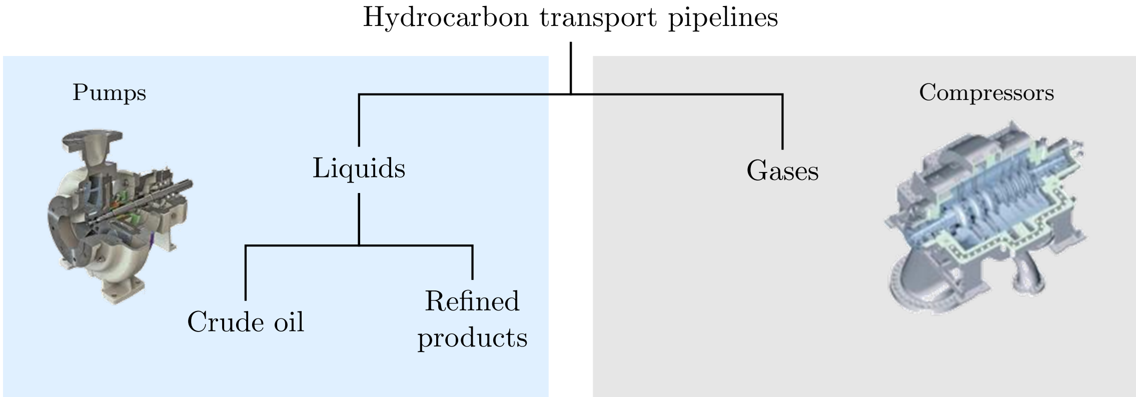


Figure 7.33. Segments of the oil and gas pipeline industry. Pumps applications are mostly confined to liquid transport

7.4 Segments of the Pipeline Industry

In Sections 7.2 and 7.3, district heating and wastewater collection were identified as industries with good potential for pump monitoring business. Both of these industries are based on fluid transportation through large pipe networks. These large, engineered pump applications are of particular interest to Sulzer for pump monitoring business and are preferred over opportunities in the configured solution business segments. Another industry of this nature that is of interest to Sulzer Pumps is the pipeline industry. In this section, the current trends and statistics from the pipeline industry are presented alongside suggested pump monitoring opportunities.

Within the hydrocarbon transport industry there are two major types of pipelines: 1) liquid (oil) pipelines, and 2) gas pipelines (Figure 7.33). Liquid pipelines can then be segmented further into those transporting crude oil and those transporting refined products. These liquid transport applications are most interesting to Sulzer Pumps since centrifugal pumps are used. Gas transport on the other hand is achieved with gas compressors.

7.4.1 Pipelines around the World

A large proportion of world pipelines are located in the United States where pipelines extend for thousands of kilometres (Figure 7.34). Other countries with significant oil and gas pipeline lengths are Russia, Canada, China, and Ukraine. Table 7.4 shows the length of pipeline transporting various substances in the ten countries with the greatest total pipeline lengths. This data is summarised in Figure 7.35 which clearly shows that natural gas transport dominates the pipeline industry.

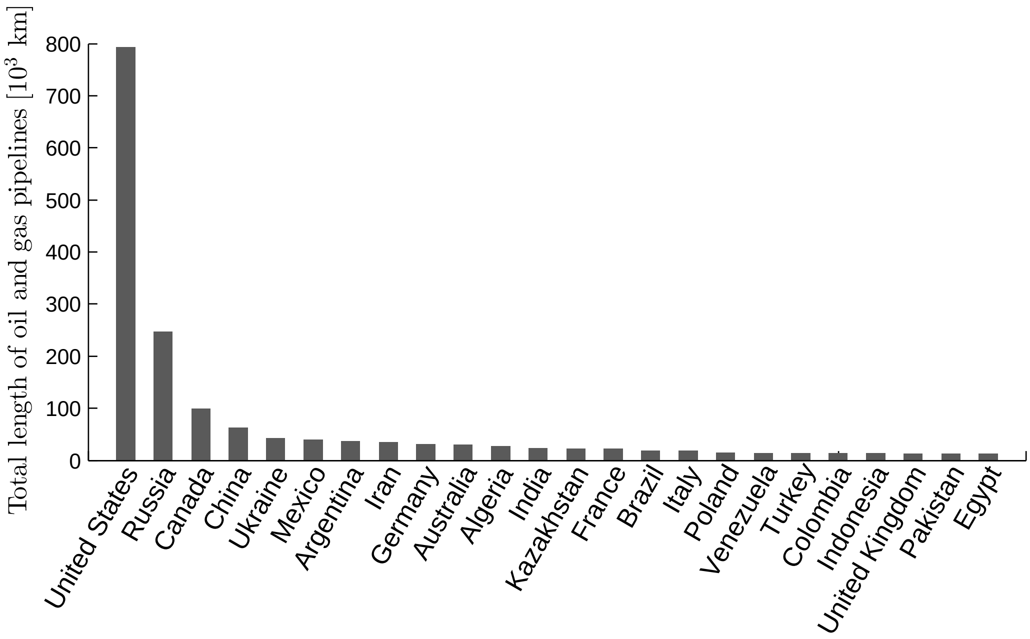


Figure 7.34. Length of oil and gas pipelines by country (*Data source: U.S. Central Intelligence Agency (2013) 2010 statistics*)

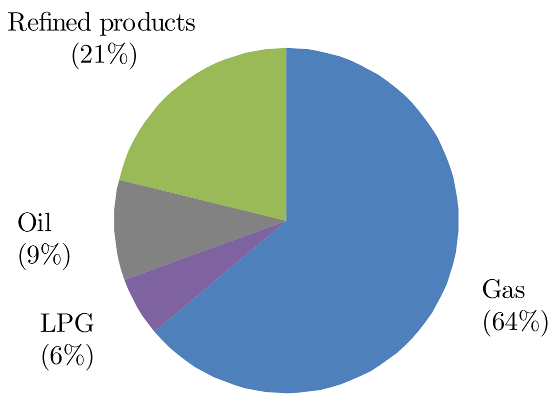


Figure 7.35. Length of pipeline by transported substance evaluated for the 10 countries with the longest total pipeline length (see Figure 7.34)

Gas pipeline compressor stations are situated along the pipeline with intervals of 80 km

Table 7.4. Length of pipelines transporting various substances in the ten countries with the greatest pipeline lengths in kilometres (*Sources: U.S. Central Intelligence Agency (2013) 2010 statistics, *American Petroleum Institute (API) and Association of Oil Pipe Lines (AOPL) (2013)*)

	Gas	LPG	Oil	Refined Products
United States	548,665		*88,510	*153,890
Russia	160,952	127	77,630	13,658
Canada	835	75,000		
China	38,566		23,470	13,706
Ukraine	36,493		4,514	4,211
Mexico	16,594	2,152	7,499	7,264
Argentina	29,401	41	6,166	3,631
Iran	20,155	570	7,123	7,937
Germany	24,688		3,687	4,875
Australia	27,900	240	3,257	
Total	904,249	78,130	133,346	299,902

to 160 km (50 mi to 100 mi (Energy Information Administration, 2007)), and in 2006 there were more than 1200 compressor stations operating in the U.S. alone (Energy Information Administration, 2007). By 2008 the number of compressor stations had increased to more than 1400 (Energy Information Administration, 2007/2008) (Figure 7.36). Opportunities in the natural gas transport segment may be preferable due to the extensive pipeline networks and the high forecasted demand for natural gas in the electricity generation industry (see Section 7.2.1). Unfortunately, compressors are used instead of pumps for gas transport (Figure 7.33) and so opportunities in this segment may be better suited to Sulzer Turbo Service than Sulzer Pumps.

Figure 7.37 shows a map of pipelines in the U.S. carrying liquid petroleum products. Pumps stations are located along these pipelines with intervals between 32 km to 160 km (20 mi to 100 mi (Association of Oil Pipelines, 2013)) depending on the terrain. Note that the average distance between pumps stations is less than that between gas compressor stations. However, compressor stations typically contain more compressors (3~5 compressors per station) than pump stations do pumps (1~2 pumps per station). Hence the length of pipeline is not necessarily a good indicator for the number of pumps or compressors on that pipeline.

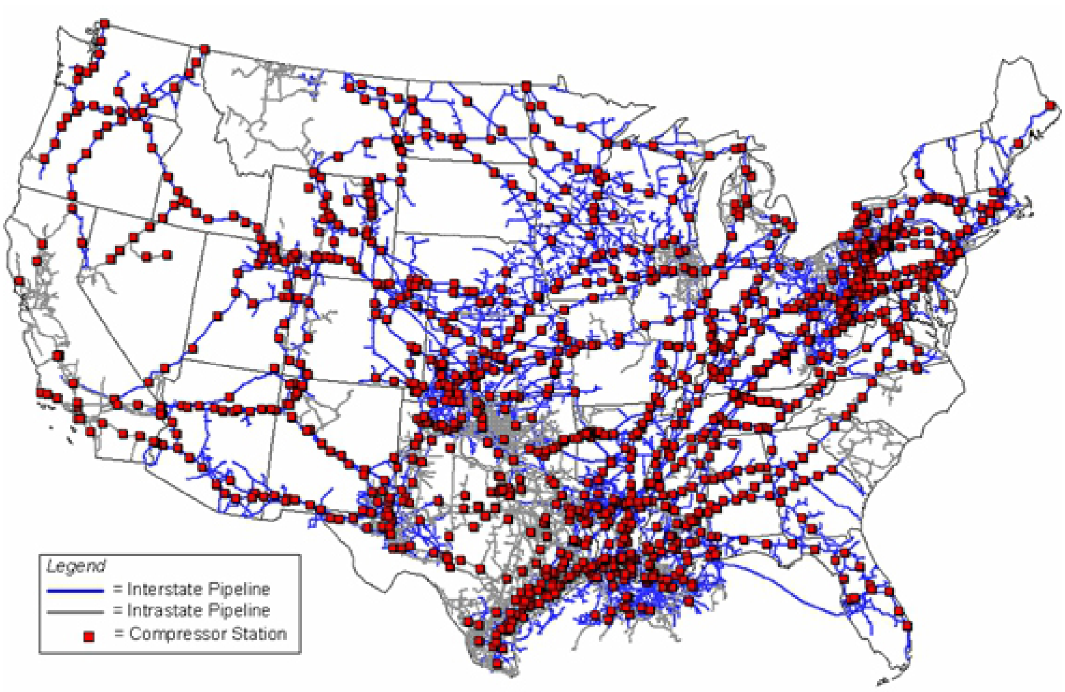


Figure 7.36. Gas pipeline compressor stations in the U.S. (*Source: Energy Information Administration (2008)*)

Assuming an average interval distance of 96 km (60 mi), and using the U.S. crude oil and product pipeline length of 244,620 km (U.S. Central Intelligence Agency, 2013), the U.S. has approximately 2,500 pump stations. Taking the total length of oil and refined product pipeline in the world to be that of the countries listed in Table 7.4 (i.e. 433,248 km), and again assuming the pump stations are placed at 96 km intervals, there are approximately 4,500 pump station in the world. Conservatively assuming that each pump station only has one pump, this is also the number or oil pipeline pumps. A total of 392 pumps are currently listed in the Sulzer ERD as either main pipeline or pipeline booster pumps. If all of these pumps are still in service, then Sulzer Pumps would have 9 % share of the estimated installed oil pipeline pumps.

Different pumps are used for pumping different oil types. Crude oil has a higher viscosity than refined products and is usually propelled with single stage centrifugal pumps in pipelines (e.g. Sulzer HSB, Figure 7.38). Rotary positive displacement pumps are also used when the crude oil has a particularly high viscosity (Moore, 2010). Also note that higher viscosity liquids have higher pipe friction losses, and so energy cost concerns may be

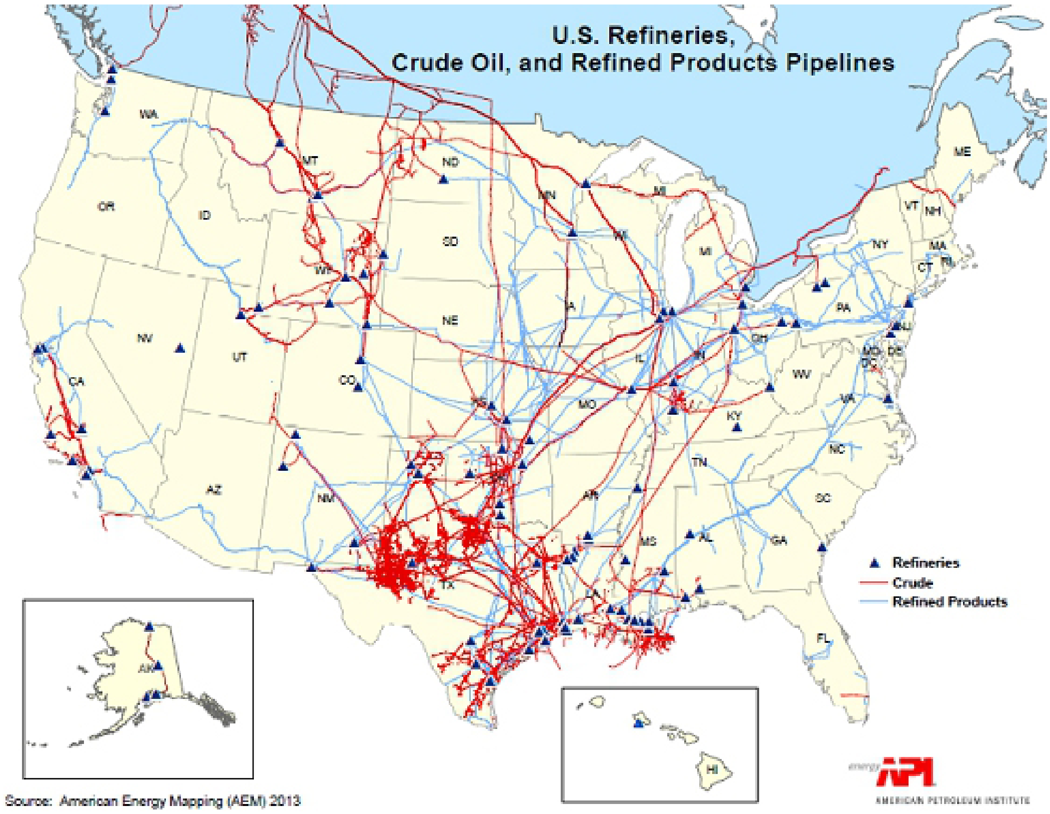


Figure 7.37. Crude oil and refined product pipelines in the U.S. (*Source: American Petroleum Institute (2013)*)

most prevalent in the crude oil transportation segment. Refined products are less viscous and more consistent than crude oil and are usually propelled by multistage pumps (e.g. Sulzer MSD or GSG pumps).

7.4.2 Monitoring Opportunities in Oil Pipelines

Pump energy costs can be the most significant life cycle cost for pipeline operators. To minimise energy costs, the energy efficiency of the pipe and pump system must be maximised. This can be achieved by operating the pump at its best efficiency point and keeping pipe friction to a minimum. Customers may be interested in pump efficiency monitoring and operating point visualisation tools to achieve these goals.

Although pipelines are generally considered as safe and reliable, pipeline leaks can be disastrous in terms of product loss, environmental damage, and public safety. Moreover,

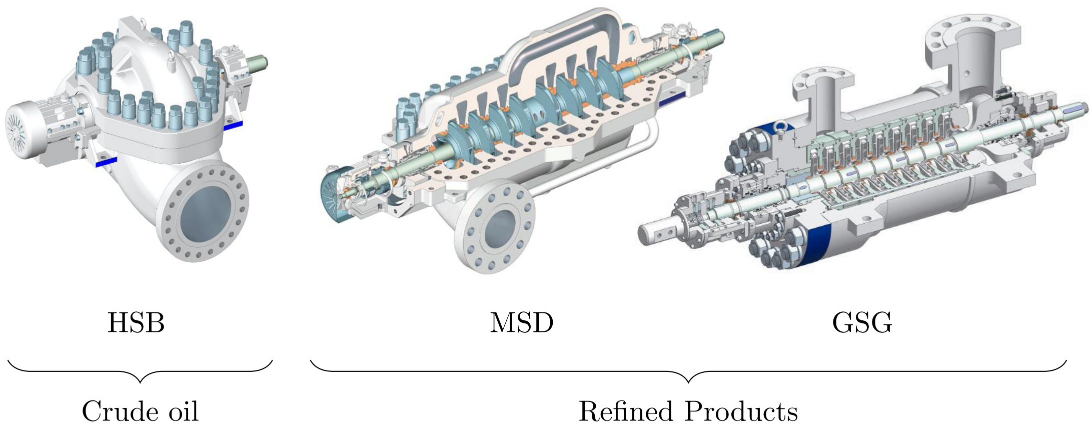


Figure 7.38. Typical Sulzer pumps used for oil pipeline applications

as in the district heating industry the integrity of aging oil pipelines is becoming a concern. Recent pipeline accidents in America have raised public criticism of the pipeline industry and concern for future pipeline projects (Frosch, 2013). As a result of these events the U.S. Department of Transport and the Pipeline and Hazardous Materials Safety Administration (PHMSA) recently reviewed the current state of leak detection systems being used in industry (Shaw et al., 2012).

Over the past five years 350 hazardous liquid onshore pipeline incidents have been reported on average annually in America (U.S. Department of Transportation, 2013). Each year these incidents have caused damage worth (on average) US$317m, while 104,000 barrels of oil are lost (U.S. Department of Transportation, 2013). To reduce the rate of incidents and incident response times, pipeline customers may be interested in advanced pipe monitoring solutions.

7.4.3 Oil Pipelines Customer Demand

Written responses to the customer demand survey (see Chapter 5) indicated that customers in the pipeline industry were most concerned with reducing energy costs. Pipeline pumps can have high power consumptions and may run 24 hours a day. Hence, small increases in efficiency can lead to dramatic energy cost savings, and therefore operating pumps at their best efficiency points is a high priority for pipeline customers. Avoiding unplanned downtime was also mentioned as an important objective. However, it was noted that critical equipment in the pipeline industry is typically spared.

Life cycle cost modelling is viewed as common practice in the pipeline segment. One customer demand survey participant estimated that around 70 % of pipeline customers in the AME business area use LCC modelling. It was also noted in survey responses that customers in the oil and gas pipeline industry keep good records of operation processes. These records may be a key resource for Sulzer for developing monitoring solutions. Since the United States and Canada hold a substantial share of the oil and gas pipeline market, future customer development should be focused in North America.

7.4.4 Competitor Solutions in Oil and Gas Pipeline Monitoring

Many monitoring services in the pipeline industry focus on monitoring the pipeline itself (rather than the pumps) since it is the main asset. Fibre optic technology can be used for detecting abnormalities in pipelines though changes in temperature and strain. Future Fibre Technologies (FFT) applies this technology for its detecting third party intrusions as part of their security services (Future Fibre Technologies, 2013) while other companies such as Omnisens and Roctest use it to detect pipe leaks and movement (Omnisens, 2013; Roctest Group, 2013). Ultrasonic and magnetic flux technologies are also used for pipe condition monitoring and are often integrated with pigging tasks (commonly referred to as 'smart pigging') (Pure Technologies Ltd, 2013; TV Rheinland Hellas, 2013).

PSI Group provides a comprehensive range of pipeline monitoring solutions for the oil and gas industry including leak detection, batch tracking, density tracking, pipeline stress monitoring, predictive simulations, and pump monitoring (PSI Group, 2013). The pump monitoring component of their services focuses on minimising pump energy consumption but also includes pump protection features.

7.5 Selecting Focus Market Subsegments

In the previous sections, the subsegments of district heating, clean water distribution, reverse osmosis desalination, waste water collection, and oil transportation pipelines were identified to have favourable business model environments for machine monitoring business cases. In this section, several factors affecting entry into these markets are presented in Sections 7.5.1 to 7.5.3 before the relative attractiveness of these markets is evaluated in Section 7.5.4. The criteria used for this evaluation are the same as those used for the focus market selection in Chapter 6 (see Sections 6.7.1 and 6.8.1).

7.5.1 Integration with Central Control Systems

For many engineered solution markets, the ability for additional monitoring equipment to integrate with existing central control and monitoring systems is very important to the customer (see Section 5.3.5). Access and data security around centralised control systems is typically taken very seriously due to the high value of controlled equipment. For the past three decades SCADA systems have been under threat from external attacks, namely hackers who attempt to interfere with their operation (Dickmann, 2009). Moreover, the perceived magnitude of security threats has increased since more and more control systems are now connected to the internet (Wilhoit, 2013). Hence any product or service that interacts with central control systems is expected to have secure and reliable communication features. This technological challenge will be a significant barrier to Sulzer Pumps entering the machine monitoring market for any of the machine monitoring applications identified in the previous sections.

7.5.2 Customer Development

Although high value contracts with customers in the engineered solution segments are appealing, demands from these customers are more complex than those from customers in configured solution segments. Moreover, the potential customer base for highly technical engineered solutions is relatively small compared to that for more general solutions. Hence the risk associated with successful customer development for monitoring business in the engineered solution segments may be significantly greater than that for business in the configured solution segments. This risk was recognised in Section 4.8.1 as a likely contributor to the SmartMonitor business venture failure, and should be considered when selecting a focus market for the current project.

Assuming an inverse relationship the value of an offer and the size of the target customer segment, Figure 7.39 shows the resulting market size. The extremes of this plot represent excessively technical offers for engineered solutions which risk unsuccessful customer development, and very simplistic offers for configured solutions which risk low profitability. Hence to minimise these risks and maximise the target market size a value proposition should be reasonably priced and appeal to a moderately sized customer base. To ensure that this condition is met in future business cases it is important to restrict the technical complexity of value propositions.

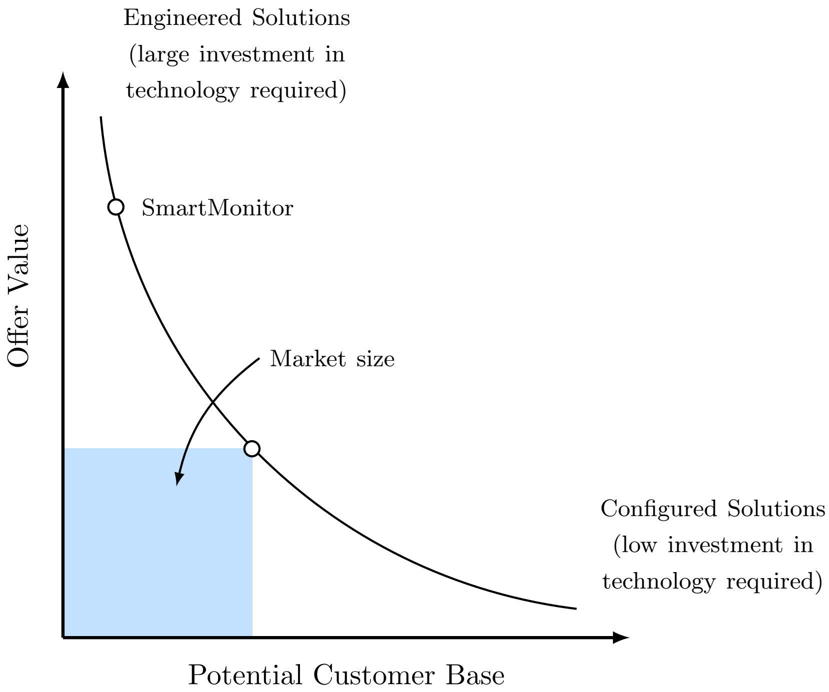


Figure 7.39. Market size as a balance between offer value and potential customer base

7.5.3 The Water Markets versus the Oil Transport Market

Throughout the past century oil has been seen as the most profitable commodity. It was a cheap source of dense energy that could not be substituted by other energy sources. Even though the power density of oil powered technology remains unrivalled, developments in renewable power generation technologies combined with climate change has relieved oil markets of some demand. Today, as the world population expands, water has become arguably the most vital commodity for a number of reasons. Table 7.5 summarises several arguments for investment in the water market over investment in the oil and gas market in terms of various business model environmental factors.

Table 7.5. Factors influencing the long term relative importance of the oil and water markets

Business environmental factors	Oil	Water
Raw material availability/ accessibility	Although oil production is still high, oil sources are becoming less accessible and the cost of oil production is increasing. For example, as onshore and shallow water reservoirs are exhausted, oil production from tar sands and deep water mining has commenced.	As the world population increases, fresh water demand also increases. However, the availability of fresh water supplies is decreasing. Consequently desalination technologies are becoming more important.
Product substitution	Demand for fossil fuel based power generation has decreased due to developments in renewable power generation technology. However, oil is far from being replaced in the transport industry due to its power density.	Water is a commodity that has no substitute since it is a fundamental requirement for life.
Regulations	Increasing requirements of emission regulations are favouring renewable power technologies.	Environmental regulations govern where water may be withdrawn from. If water local water intake is not practical or does not comply with environmental regulations then water is often transported from remote locations via pipelines.

7.5.4 Focus Market Subsegment Selection

In this section, the attractiveness of machine monitoring opportunities in the subsegments of district heating, clean water distribution, reverse osmosis desalination, waste water collection, and oil transportation pipelines are evaluated in a qualitative manor. The evaluation uses a selection of the market attractiveness and competitive position criteria set out in Sections 6.7.1 and 6.8.1 respectively. The chosen criteria were those that are not based on market feedback since Sulzer is not yet offering machine monitoring in the majority of the aforementioned markets, with the exception of the waste water collection machine monitoring market. No ranking or scoring system was implemented as this information was only intended as a guideline for Sulzer management to decide on a target market.

Market attractiveness

Customer needs

All of the markets short listed in Section 7.5.4 demand both reliability and energy efficiency for cost saving purposes. However, the demand balance between these two objectives is different for each market. Customers in the district heating, clean water distribution, and reverse osmosis markets are currently biased toward energy saving goals since water handling networks are relatively reliable. In contrast, the current public debate in the U.S. around oil pipeline safety in combination with the low accuracy of leak detection equipment (Song, 2012), reliability is likely to be the focus of oil pipeline companies at present.

Also depending on the market, customers will have different data transmission requirements. For example, customers in the reverse osmosis market may be satisfied with local data acquisition and transfer since all of their operations are contained within a plant. However, customers in the district heating, clear water distribution, and oil transport pipeline market will demand remote sensing and long distance data transfer due to the distributed nature of their operations. The current knowledge and experience of Sulzer Pumps (Section 7.5.4) should be compared with these customer needs to identify the markets where Sulzer Pumps can offer the most added value.

Competitive situation

Clean water distribution and wastewater collection is demanded worldwide as necessary and critical infrastructure. Hence there are a large number of competitors in these markets. Moreover, Jörgen Jäger (from Sulzer ABS wastewater solutions) states that market competition can vary significantly by region and only a few large companies have a global presence. Hence a robust business model capable of withstanding that of many different competitors will be required for secure business in these markets.

Competitors in the clean water markets such as Xylem currently hold the largest market shares since they offer a full range of monitoring solutions. For example, they offer both equipment monitoring and water quality monitoring solutions making them a convenient ‘one-stop-shop’ for customers. These competitors with diverse product ranges may be Sulzer Pumps largest barriers to market entry.

The vast majority of the oil pipeline industry is based in the U.S., and just five companies in the U.S. oil pipeline market account for approximately 86 % of the U.S. industries revenue (Morgan, 2013). Hence competition in the oil pipeline market is mature and highly concentrated. Furthermore, this market is expected to remain like this due to the high capital costs of pipelines imposing a cost of entry. With only five major customers in the market potentially requiring machine monitoring, market entry and customer development may be difficult for Sulzer Pumps.

Legislation and regulations

Regulations governing activities in the district heating and water industries vary with country and region. There are often many regulations governing water quality, but relatively few governing water transport. Some relevant regulations which support machine monitoring business in these markets are mentioned in Section 6.5.1, Section 6.5.2, and Section 7.2.2.

Over recent years the pipeline industry has been in the public spot light due to debate over environmental and social issues concerning the proposed Keystone XL pipeline project (Parfomak, Pirog, Luther, & Vann, 2013). These debates have significantly delayed approval of the presidential permit required to construct the international Keystone

XL pipeline and have also raised public awareness in safety issues associated with oil transportation. Current oil spills involving different means of transportation have fuelled debates and attracted negative publicity (Frosch, 2013; Haggett, Sherwood, & Podkul, 2013). Overall, these circumstances create a pressure on machine monitoring equipment and service providers to perform with a high degree of precision, as underperforming may result in bad publicity and possible legal action taken against them for oil spill liabilities. Hence, a thorough risk analysis is recommended before entering into the oil pipeline machine monitoring market.

Technology maturity and standardisation

Currently offered technology in all of the suggested markets is not considered mature and leaves room for further innovations and development. Smart water network solutions are still in the development phase with technology being trialled over limited network areas in the U.K. (SmartReach, 2013). Some smart water distribution and wastewater collection solutions are currently being offered by some competitors (see Sections 7.2.2 and 7.3.3 respectively). However, these solutions are relatively young and far from standardised.

Oil pipelines companies still carry out manual inspections of equipment and are interested in automated methods to save labour costs and increase monitoring site resolution (Sulzer, 2012). However, permanent and continuous online solutions of the past decade are deemed to be underperforming as only 5 % of pipeline spills are successfully detected (Song, 2012). Hence there is a drive for more accurate and reliable pipeline monitoring solutions to be developed.

Sulzer's Competitive Position

Investment intensity

Since Sulzer Pumps already has a complete offering in the wastewater collection machine monitoring market, business model development here will not be hindered by extensive research and development resource requirements. Moreover, since research and development requirement are minimised, the investment intensity to develop a business model for this market will also be minimised. Business cases in other markets must factor in significant time and resources for technical research and development which will lead to a prolonged entry into the market.

Experience and knowledge

With the acquisition of Cardo Flow Solutions (Sulzer Ltd, 2011a) in 2011, Sulzer gained the knowledge and experience accumulated by Cardo Flow staff members who developed the ABS pump control and monitoring solutions range. These are arguably the most advanced control and monitoring solutions offered by Sulzer Pumps at present, and so the experience of these former Cardo Flow Solutions staff will be invaluable for future product developments and technical sales support. Although, the skills and experience of these staff members is transferable to other markets, it is strongest in the wastewater collection markets. Hence, the competitive position of Sulzer Pumps based on its experience and knowledge base will be best in the wastewater collection market.

Interaction with other business segments

All of the proposed markets contain opportunities involving optimising pressurised fluid networks except the wastewater collection market in which networks are not often under significant pressure. The oil transportation pipeline and reverse osmosis desalination markets are likely to have simpler monitoring requirement compared to the district heating and clean water distribution markets since their pipe networks are considerably less complex. Hence either the oil transportation pipeline or reverse osmosis desalination markets would be favourable for entry with basic fluid network monitoring solutions.

Focus Market Selection Summary

After presentation and discussion of the investigation results shown in this chapter, Sulzer management decided that the most interesting markets to Sulzer Pumps for machine monitoring business were the waste water collection market and the oil pipeline market. Sulzer Pumps currently offers pump control and monitoring solutions in the waste water collection market (ABS control and monitoring products and services). However, sales of these solutions have been less than expected. In order to understand the low sales figures, an investigation into the current ABS business model is presented in the following chapter.

The oil pipeline market was also favoured by the current Sulzer Pumps management team, and so concept business models for machine monitoring offering in this market are suggested in the next chapter.

7.6 Summary

In this chapter, the value chains of the power generation, water, and pipeline industries were identified to expose possible machine monitoring opportunities. This summary includes the main business model environmental factors that were discovered (Section 7.6.1), along with the most appealing machine monitoring opportunities (Section 7.6.2). From these opportunities, two focus markets were chosen to further refine the scope of this study. Factors favouring the selection of these two markets are summarised in Section 7.6.3.

7.6.1 Business Model Environmental Factors

Business model environmental factors within the power generation, water, and pipeline industry were investigated in this chapter. The following provides a summary of the findings:

Power generation

1. Conventional fossil fuel electricity generation continues to dominate existing and planned infrastructure. However, as regulations drive the share of renewable energy power plants up, the most flexible and efficient conventional technologies are being favoured, namely combined cycle power plants.
2. As nuclear power plants are retired, their capacity is often taken up by conventional fuels, particularly coal.
3. Wind powered electricity generation has the highest forecasted growth in the renewable power generation infrastructure market. Unfortunately, wind electricity generation does not require pumps and so machine monitoring opportunities for Sulzer Pumps are not favourable.

4. Most pump monitoring opportunities in electricity generation are within thermal power plants. However, the majority of downtime for thermal power plants stems from issues with other equipment, i.e. heat generation equipment and generators. These opportunities may be better suited to Sulzer Turbo Services.
5. Growth in the district heating market is driven by demand for energy efficiency and reduced carbon emissions.

Water

1. The balance between investments maintaining current water networks and investing in new network infrastructure varies significantly by country.
2. The balance between municipal and industrial water usage varies significantly by country.
3. As the world population increases so does demand on clean water production. In some parts of the world, a significant proportion of ground and surface water resources are already under strain, and hence desalination plants are becoming more common. Reverse osmosis is the most common desalination process, and has a heavy reliance on pumps.
4. Although the primary goal of municipal clean water and wastewater pump operators is maintaining process functionality, energy accounts for a significant proportion of their costs. Hence energy management schemes are of great interest.
5. Some advanced wastewater treatment plants have become energy self-sufficient by using biogas produced during nutrient removal processes to fuel combined heat and power plants.

Oil and gas pipelines

1. The vast majority of world oil and gas pipelines are in North America. Moreover, the U.S. and Canada are planning to construct more oil and gas pipelines to become independent from fluid fossil fuel imports. Other countries with significant lengths of oil and gas pipelines are Russia and China.

2. A combination of controversial environmental planning and accidents involving pipelines has assisted public protest against the Keystone XL project.
3. Energy costs are the primary concern for pipeline companies at present according to Sulzer CSS and sales staff.

7.6.2 Value Propositions and Customer Segments

After identifying the current business model environment within various segments of the power generation, water, and pipeline industries, several machine monitoring opportunities were made apparent. The value proportion and customer segment pairs described hereafter were deems to hold the greatest potential for future business models.

District heating

Variation in the age and quantity of world district heating infrastructure by country yields two main monitoring opportunities. Firstly, pipeline leak detection is important for old deteriorating infrastructure, and secondly, network optimisation is of interest for new projects and retrofit business. Value associated with these solutions is reduced energy and maintenance costs, which is beneficial to municipalities and utility companies operating district heating networks.

Clean water distribution

Several opportunities to offer value through machine monitoring exist in the area of smart water networks. However, these opportunities usually demand development of or integration with advanced centralised control solutions which is not in Sulzer Pumps scope of expertise. Furthermore, competition in this market comprises several large electronics and software firms which have extensive experience with these types of solution and so the risk of product substitution will be high. Customers in this market include private and public water utilities and also EPC companies responsible for specifying new equipment.

Reverse osmosis

Reverse osmosis is the most common process for desalination and it relies on pumps to force saltwater through membranes. This process is very energy intensive and so energy management and pump optimisation opportunities are likely to exist. Similar to clean water distribution, both utility operators and EPC companies would be potential customer segments in this market.

Wastewater collection

Waste water collection demands machine monitoring for both pump network reliability and network efficiency. Network reliability is paramount for environmental protection and public safety, while network efficiency is demanded to reduce network operating costs. Municipal utilities will be the primary customer segment in this market. However, EPC companies specifying new equipment will also be an important customer segment to acquire.

Oil transportation pipelines

Oil pipeline pumps consume large quantities of energy since they may run 24 hours per day. Minimising pump energy costs directly affects the profitability of a pipeline and hence pumping efficiency and energy management are very important to pipeline operators. Due to the distributed nature of pipeline equipment opportunities also exist in automated remote monitoring of pump stations for reliability. Customers segments in the oil pipeline industry would include independent pipeline companies, oil and gas companies invested in pipelines, and EPC companies associated with new projects.

7.6.3 Selection of a Focus Market Subsegment

Given the information presented in this chapter, Sulzer management decided that machine monitoring business model development in the wastewater collection and oil transportation pipeline markets would be most interesting for Sulzer Pumps in its current position. A decision was also made to analyse the existing ABS pump control and monitoring business model before evaluating the current ABS control and monitoring technology for application on oil transportation pipeline.

Chapter 8

Oil Pipeline Equipment Monitoring Business Feasibility

8.1 Introduction

The oil pipeline industry demands energy efficient and trouble-free operation from pumps to sustain their business. Sulzer Pumps has been interested in satisfying these demands since Sabine Sulzer first proposed a business case for offering predictive maintenance equipment and services targeted to the oil pipeline industry (Sulzer, 2012). The work in this chapter further examines the feasibility of this business case in the current business model environment.

8.1.1 Objective

The goal of the work presented in this chapter was to firstly determine if the current ABS wastewater pump controllers would be suitable for applications in the oil pipeline industry, and secondly, to determine whether the customer in the oil pipeline market would be interested in purchasing this solution.

8.1.2 Method

To achieve the previously mentioned goals, the technical specifications of the ABS pump controllers were compared to the machine monitoring solution specifications requested by ConocoPhillips (2011). This allowed the common machine monitoring requirements of the wastewater segment and the oil pipeline segment to be identified along with the technology required by Sulzer Pumps to enter the oil pipeline machine monitoring market. Next, the suitability of the ABS pump controllers for application in the oil pipeline industry was evaluated from the perspective of the customer via communication with Sulzer Pumps Alliance Managers that work closely with Sulzer Pumps customers in the oil pipeline industry.

8.2 Industry Demands versus Sulzer Pumps Current Capabilities

The condition monitoring demands of the entire oil pipeline industry were assumed to be similar to those specified by ConocoPhillips (2011). Within their request for proposal (RFP) they split their condition monitoring requirements into two categories, 1) vibration monitoring and 2) lubrication and oil analysis, and state that their overall primary objective was to obtain reliable information about the condition of their equipment to avoid unexpected failures and better plan maintenance. Details of these two request categories are compared with Sulzer Pumps current capacity in the following sections.

8.2.1 Vibration Monitoring

The ConocoPhillips RFP specifies that three axis vibration measurements should be taken from rotating equipment at pipeline pump stations as well as terminal stations. The equipment specified in the RFP were:

1. Motors
2. Centre hung pumps
3. Overhung pumps

4. Vertical pumps
5. Reciprocating engines
6. Gas turbines
7. Gear boxes

Alarm and protection trip points based on vibration level are specified by ConocoPhillips, and so functionality to customise these features in monitoring equipment would be required. Electrical devices used at ConocoPhillips must meet the requirements of devices suitable for use in a Class I (flammable gases and vapours) Division 2 (abnormal conditions, i.e. the hazard is usually contained) hazardous location as set out by the U.S. Occupational Health and Safety Administration.

➢ Sulzer ABS monitoring equipment has been designed specifically for monitoring pumps (predominantly of the vertical axis submersible type) with their respective motors in the wastewater industry. Hence, the Sulzer ABS control and monitoring products manager, Jörgen Jäger states that the current Sulzer ABS control and monitoring equipment is not suitable for fulfilling the ConocoPhillips request. However, he believes that the research and development staff in Sweden have the required knowledge for developing hardware and software solutions for this application.

➢ The Sulzer pump testing facility in Portland has a program for monitoring pumps (written in LabVIEW 8.5). Sulzer testing engineer, Ralph Stark, says that it would be suitable for condition monitoring of pumps.

Vibration Data Collection and Management

ConocoPhillips specified manual data may be collected manually on a monthly basis for pipeline equipment and on a quarterly basis for terminal equipment. However, data collection frequencies should be optimised as monitoring services are established. As well as manual data collection, ConocoPhillips were also open to remote online monitoring. Data was to be stored in ConocoPhillips Livelink Repositories and owned by ConocoPhillips. Database access would be granted to the monitoring company who would be responsible for database management.

- Although some current Sulzer ABS pump control and monitoring products are capable of acquiring vibration data, Jörgen Jäger states that this equipment is not suitable for directly satisfying the needs of ConocoPhillips RFP. Vibration measurements are not a strong point of the ABS control and monitoring product development team. However, with input from the machinery dynamics and acoustics department the development of a suitable product would be easily achievable.

- Currently, ABS solutions can easily integrate with SCADA systems. However, they have limited compatibility with other software solutions such as data repositories. Data from ABS control and monitoring equipment can be managed via the ABS AquaWeb software. Jörgen Jäger suggests that data exchange process could be established between AquaWeb and other database management software if required.

Vibration Data Analysis

The ConocoPhillips RFP specifies that the contracted monitoring company must provide vibration data analysis software on a wide area network (WAN) for experts and engineers to review detailed data. The main purpose of this request is to support these experts and engineers reviewing recommendation reports from the contracted monitoring company. Additionally, the contracted monitoring company was requested to host a web based reporting system through which authorised ConocoPhillips personal may access data and reports.

- Frank May (Sulzer head of machinery dynamics and acoustics) stated that Sulzer does not currently have software solutions such as that described above. To meet this request Sulzer would have to find a software partner.

- Sulzer may be able to develop such software by utilising the skills and knowledge of its vibration experts and software development staff. However, such developments may require significant periods of time.

Vibration Data Analyst Certifications

ConocoPhillips RFP specified that vibration analysts interpreting vibration data must be certified by the international standard ISO 18436-2 (International Organisation for Standardisation, 2003b) and the American Society of Non-destructive Testing (ASNT) certification SNT-TC1A (American Society for Non-destructive Testing, 2011).

- ➢ Sulzer Innotec Head of Machinery Dynamics and Acoustics, Frank May, states that although Sulzer Innotec vibration analyst staff do not hold these certifications at present. However they would not be difficult to obtain, i.e. Sulzer vibration staff have the skills required for obtaining these certificates.

8.2.2 Lubrication and Oil Monitoring

In addition to vibration monitoring ConocoPhillips also requested that oil and lubrication in the applicable machines listed in Section 8.2.1 be monitored. The following tests were of interest:

1. Emission spectroscopy (21 wear, additive, and contaminant metals in ppm)
2. Viscosity at 40°C (Centistokes)
3. Total acid number (mg KOH/GM sample)
4. Karl Fischer Water Titration (Water in ppm)
5. ISO particle count (ISO cleanliness classification – centrifugal and hydraulic systems)
6. Direct read ferrography (DRS and DRL – All others except centrifugal and hydraulic systems)
7. Wear particle analysis (Micro examination of particles)
8. Water source determination (Profiling of excessive water when free water is present in sample)
9. Filter analysis
10. Deposit/Scale analysis
11. Refrigerant analysis

12. Coolant/Glycol/Process water analysis
13. Grease analysis
14. Micro Exam/Analytical ferrography
15. Other special and ASTM tests to be available upon request

ConocoPhillips also specify that laboratory instrumentation should meet the relevant standards from the American Society for Testing and Materials (ASTM) and the International Organization for Standardization (ISO) to ensure reliable measurements.

- ➢ Sulzer Metco tribology and lubrication specialist, Ueli Buxtorf, states that Sulzer Innotec does not do any of the above lubrication and oil tests in-house since it is significantly cheaper to outsource this work to specialist laboratories. Furthermore, Sulzer Innotec only has equipment for providing viscosity measurements.
- ➢ Currently Sulzer outsources oil analysis to OelCheck who have laboratories in Germany and China.
- ➢ Specialist lubrication and oil analysis companies such as OelCheck are often certified by the appropriate standards organisations to do the listed tests. For example, OelCheck claim that its employees are certified by the Society of Tribology and Lubrication Engineers (STLE) as Certified Lubrication Specialists (CLS). They are also active members in the ASTM and DIN (Deutsches Institut für Normung) standards organisations.
- ➢ Sulzer Innotec water, wastewater, and asbestos analyst, Roger Häusermann, is capable of analysing process water in-house. However, the types of process water that can be analysed with the current equipment at Sulzer are limited.

Lubrication and Oil Data Collection and Management

The ConocoPhillips RFP specifies that oil samples should be collected from engines on a monthly basis and from gearboxes on a quarterly basis. As suggested with the vibration monitoring work request, these monitoring intervals may be adjusted as required to optimise the monitoring process once a monitoring schedule has been established. Data management for oil and lubrication monitoring is the same as for the vibration monitoring component of the RFP which is mentioned in Section 8.2.1.

- ➢ Ueli Buxtorf (Sulzer Metco lubrication and tribology specialist) has advised that Sulzer does not deal in lubrication and oil sampling equipment as these are usually specified and supplied by specialist laboratories where the samples are analysed.

Lubrication and Oil Data Analysis

ConocoPhillips specify in their RFP that data interpretation and diagnostics are expected to be done as per ISO 13379:2003 (International Organisation for Standardisation, 2003a). Hence, analysts should be familiar with this standard.

8.2.3 Summary of Sulzer's Capabilities

While there is no doubt that Sulzer has the potential to become a leading pump condition monitoring solution supplier, the needs of the oil pipeline industry (indicated by the ConocoPhillips RFP (ConocoPhillips, 2011)) are very demanding in terms of technology and experience. These are two things that Sulzer Pumps currently does not have in area pipeline condition monitoring. Nevertheless, Sulzer submitted a proposal to ConocoPhillips in response to their RFP. However, Sulzer lost the bid to competitor SKF.

Sabine Sulzer (the Innovation Manager at the time) and Frank May (Head of Machinery Dynamics and Acoustics) visited the U.S. in January 2012 to evaluate potential for condition monitoring business. During this time, they interviewed several alliance managers and pipeline customers to obtain a perspective on customer needs. Key feedback from these meetings regarding Sulzer's current position and capacity to response to the pipeline industries condition monitoring needs are summarised in the following subsections.

Competitive Knowledge and Experience for Oil Pipeline Condition Monitoring

Field service and support manager, Dennis Bruce, is responsible for managing subcontracted condition monitoring services for Sulzer Pump. While commenting on Sulzer's capacity to fulfil the work proposed to ConocoPhillips (in response to their RFP) he said that “For us (Sulzer Pumps) to start, we probably could have done some portion of it (the proposed work) within a quarter, within three months. But not the entire thing, it’s just too big.” This statement agrees with the evaluation of Sulzer’s capacity to fulfil the ConocoPhillips RFP (Section 8.2.1 and Section 8.2.2) by suggesting that Sulzer currently lacks the machine monitoring technology and experience required to establish condition monitoring services for customers in the oil pipeline industry in a timely manner. Hence, Sulzer is at a major disadvantage to competitors who own mature condition monitoring technologies and have established track records in providing condition monitoring services.

Sulzer Pumps lack of experience and know-how is also apparent to Sulzer customers, particularly when compared directly to competitors. For example, in the 2012 interview with ConocoPhillips pipeline staff, rotating equipment expert Alan King commented on supplier selection for condition monitoring services and said: “There’s some major players that are in the vibration and analysis field. Sulzer’s not one of them. I mean not a major player in vibration, no. Not here, not in the United States.”. In contrast Alan King was impressed by the capabilities of Pro Pump Services, a small company which Sulzer Pumps subcontracts work to. However, he concluded that they were under resourced based on their slow turnaround. Alan stated “They’re (PPS) very good at what they do, but they’re also very limited on their resources, which means that they go out and do something but then it takes them forever to get us the information for Sulzer. But Sulzer needs it to make good decisions for us (ConocoPhillips). So that tells me that the staffing level is not right.”

Sulzer has the in-house knowhow to develop condition monitoring technology to suit the pipeline industry. However, few resources are allocated to condition monitoring solution development in general which in turn stifles Sulzer Pumps from picking up work in this high-tech area. In the meeting with Dennis Bruce in 2011, Sabine Sulzer mentions that “there is some experience (at Sulzer), but this is just in ABS, there are just 2 or 3 guys, with Jörgen Jäger, and they’re completely tied up. So there is no possibility that we can take the resources of them (the ABS control and monitoring team) and really think of adapting it to other situations”. Sadly, recent correspondence with Jörgen Jäger confirms that this is still the case since a significant portion of their time and budget is spent on product line maintenance (Section 9.9). In the same meeting, Dennis Bruce also expressed concerns from the customers on Sulzer's commitment to providing condition monitoring services. This reflects on the fact that Sulzer has not built a reputation for condition monitoring yet, which will make it difficult for Sulzer to compete with more experienced competitors. To address this point, it is recommended that Sulzer focus on establishing solid customer relationships in its initial condition monitoring projects in order to shape a reputation that reflects visions of the future company image.

Current Activities in Oil Pipeline Condition Monitoring

Due to Sulzer's lack of experience and equipment in condition monitoring, services in this area provided to the oil pipeline industry in the U.S. are currently outsourced to Pro Pump Services, Bethlehem, Pennsylvania. Dennis Bruce, a field support and maintenance manager for Sulzer Pumps states that "Their (PPS) experience at this work is superior to ours". Although Sulzer does not currently place any mark up on services subcontracted to PPS, Sulzer benefits from all the repair and field service work identified by them.

Although SKF placed the winning bid for ConocoPhillips pipeline (now Phillips66) condition monitoring proposal, Sulzer Pumps still supply field testing services. Dennis Bruce states that these services are often subcontracted to Pro Pump Services, but sometimes they are performed by a Sulzer Pumps Phillips 66 field engineer or alliance manager. Dennis Bruce also says that Sulzer Pumps is currently providing condition monitoring services to Chevron's upstream operations in Crane, Texas, via PPS. Sulzer Pumps is also currently proposing condition monitoring services to Chevron's pipeline business in Beaumont, Texas.

8.3 A Concept Business Model for Machine Monitoring in the Oil Pipeline Industry

Figure 8.1 shows a concept business model for providing condition monitoring services in the oil pipeline industry based on the 2011 ConocoPhillips RFP (ConocoPhillips, 2011).

For providing vibration monitoring services, key resources and activities are the crux of the business model. Firstly Sulzer must invest in manufacturing or purchasing measurement equipment suitable for the customers needs and then secondly obtain qualified and certified staff to acquire, communicate, manage and interpret measurement data. Since vibration monitoring will not require ongoing purchasing of equipment or highly specialised equipment (relative to lubrication monitoring) the business model does not rely so much on key partners in this area.

To engage in lubrication and oil monitoring activities in the oil pipeline industry, Sulzer would either need to heavily invest in lubrication and oil analysis laboratory facilities, or found a relationship with a key partner in this area. Currently, Ueli Buxtorf, a tribology and lubrication expert employed by Sulzer Metco uses the services of OelCheck for consulting purposes. OelCheck provide a comprehensive range of lubrication, oil, and coolant analysis services. However, they lack refrigerant analysis capabilities. Other companies such as Herguth Laboratories Incorporated can test all of the fluids that ConocoPhillips requested monitoring for.

Alternatively, some customers in the pipeline industry may be able to provide oil analysis services as most major oil companies have specialist lubrication and oil analysis laboratories. For example ConocoPhillips offers the AnalysisPlus lubrication analysis program (ConocoPhillips Company, 2007). Similarly, Chevron offers their LubeWatch oil analysis program (Chevron U.S.A. Inc., 2012), and Shell offer their Rapid Lubricants Analysis (RLA) Oil and Equipment Monitoring Service (Shell International Petroleum Company Limited, 2012).

Sulzer competitors have proven that contract machine monitoring is a viable business case in the oil pipeline industry though obtaining customers in this market. However, in this market there are a small number of large opportunities which creates a highly competitive environment. To compete successfully in this market, previous experience with proven solutions is essential for convincing the customer that Sulzer is more capable than other competitors for satisfying their monitoring needs. Unfortunately these are two qualities that Sulzer does not have, and is the most likely reason for Sulzer not winning the machine monitoring work recently requested by ConocoPhillips (2011).

Key Partners

- A lubrication and oil analysis laboratory
  1. Third party specialist, e.g. OelCheck
  2. Laboratory services of the customer if available
- Oil sample disposable equipment supplier
- Data communications carrier
- Vibration data analysis software developer/supplier
- Data repository and reporting software developer/supplier
- IT support company

Key Activities

- Taking oil samples
- Interpreting oil analysis results
- Interpreting vibration data
- Trending monitoring data
- Documenting recommendations
- Maintaining IT infrastructure and database management

Key Resources

- Certified vibration experts
- Oil and lubrication experts
- IT equipment and staff
- Oil sample collection staff
- Vibration measurement equipment
- Communications equipment

Value Proposition

- Vibration, oil and lubrication monitoring services for:
  - Higher pumping efficiency
  - Lower energy costs
  - Higher machine reliability
  - Increased workplace safety
  - Reduced downtime
  - Reduced maintenance costs
  - Decreased maintenance time
  - Increased feasibility to remove redundancies
  - System feedback for better control
  - Grounds for improving the company's public image

Customer Relationship

- Sulzer to provide an independent monitoring service alongside the customers normal operations
- Sulzer monitoring staff would be available for consultation advise with machinery

Channels

- Predominantly contract work acquired by sales staff
- Private negotiations over contract specifics
- Regular billing period in contract
- Reports are delivered through online repositories
- Sulzer staff would be available for decision making support

Customer Segments

- Oil pipeline operators
  - Operate high value centrifugal pumps
  - Revenues made by pumped quantities
- May be extended to other pipeline operators. E.g.:
  1. Gas pipelines
  2. Water transport pipelines

Cost Structure

- Vibration data analysis software license fees
- Oil analysis services, e.g. OelCheck: €29.00 - €123.00 per sample
- Oil sample consumables and transport costs
- Oil sample collection staff transport costs
- Vibration measurement equipment costs
- Data communications costs
- Staff wages
- IT support costs
- Administration costs

Revenue Streams

- Financial
  - Monitoring service fees
- Non-financial benefits
  - Insight into pump usage in the pipeline industry
  - Closer relationship with pipeline customers
  - Possible repair and service work
  - Performance and lifetime data on pumps (either Sulzer pumps or competitor pumps)
  - Machine monitoring experience, possibly with customer testimonies/recommendations

Figure 8.1. A concept business model for providing vibration and lubrication monitoring services to the oil pipeline industry

In responses to this situation, Sulzer should consider serving other industries with machine monitoring requirements. In particular, Sulzer should consider entering markets with less established solutions and competition. This will give Sulzer the opportunity to develop solutions with customers and to gain valuable knowledge and experience with machine monitoring to stay ahead of the competition.

8.4 Current Customer Interest in the Oil Pipeline Industry

The most recent investigations into U.S. pipeline customer interest in condition monitoring services were the customer interviews conducted by Sabine Sulzer and Frank May in January 2012. Since this was over one year ago the alliance managers were contacted again to obtain an up-to-date view on customer demand. Their responses are shown in Table 8.1.

Just five pipeline companies account for the vast majority (86 %) of the industry revenues (Morgan, 2013). Hence, developing business with these key players would be essential for obtaining a respectable market share. Sulzer already has alliances with BP, Shell, and Enbridge (see Table 8.1). However, Sulzer has no alliances with the two major players TransCanada and Plains All American Pipeline companies. Publically available information about the machine monitoring practices of TransCanada and Plains All American Pipeline mainly refer to machine monitoring activities for ensuring pipeline integrity rather than for optimising pipeline life cycle costs. Details of these activities are shown in Table 8.2.

Although the greatest lengths of pipeline are located in the U.S. (Section 7.4.1), Russia and China are also have vast lengths of pipeline potentially requiring monitoring services. In Russia, the state owned enterprise Transneft holds a monopoly over the Russian pipeline industry. Hence they would be a key customer in the Asian/European markets. Russian pipelines connect to China at border east of Mongolia. This pipeline is managed by the Chinese state owned enterprise China National Petroleum Corporation (CNPC) on the Chinese side. CNPC have their own pipeline construction company, SPCC, which would be a major potential customer in the Asian market.

Table 8.1. The view of Sulzer alliance mangers on condition monitoring business in the oil pipeline industry

Bruce Susilovich states that Phillips 66 pipeline company (formally ConocoPhillips pipelines) is working with SKF to satisfy their condition monitoring requirements. He also states that "at this time there is no other opportunity for us (Sulzer Pumps) with Phillips 66".

Rick Hannegan says that Sulzer is currently providing condition monitoring services to Chevron. However, they are providing these services through sub-contractor Pro Pump Services.

Pat Hudgens is unaware of if Enbridge condition monitoring activities.

Christopher Schempf reported that Marathon uses a central SCADA system located in Findlay, Ohio, to monitor alarm and shutdown events at their pipeline stations. Additionally each station has a computer for gathering bearing temperature, case temperature, and vibration data which they use for trending. Christopher states that he does "not see a clear path in this market for Sulzer".

Paul Christnacht reported that he has recently discussed pipeline machine monitoring with ExxonMobil. However, unfortunately ExxonMobil expressed that they were satisfied with their current solutions and were not interested in perusing alternative solutions at this time. Paul also mentions that at ExxonMobil it is difficult for pipeline projects to compete for internal funding against the more attractive production projects. This competition results in pipeline projects having relatively small capital expenditure budgets which do not allow for investment in additional condition monitoring solutions.

Could not comment in the timeframe of this investigation.

Could not comment in the timeframe of this investigation.

Table 8.2. Pipeline monitoring commitments of TransCanada and Plain All American Pipeline

TransCanada In business to deliver	TransCanada pipelines are controlled and monitored from a central location which is manned 24 hours per day (TransCanada Corporation, 2013). They also have automated leak detection systems installed throughout. Over the last two year (2011 and 2012) TransCanada has invested \$1.4 billion (US) in pipeline safety, maintenance and integrity programs (Meier, 2013).
PLAINS ALL AMERICAN PIPELINE, L.P.	Plains All American pipelines are controlled and monitored from one of two central control rooms. These stations receive real-time data from sensors distributed throughout the pipeline. Maintenance and repairs are performed on schedule or when necessary (Plains All American Pipeline L.P., 2013).

8.5 Summary

Some of the best opportunities for machine monitoring in the oil pipeline industry are in leak detection since this is becoming a required safety practice. For example, a leak detection system is condition for the Keystone XL project (U.S. Department of State, 2013). Machine monitoring for efficiency optimisation and predictive maintenance is also attractive, but it is not only for pipeline company profitability rather than regulatory requirements.

The viability of condition monitoring business cases has been proven by Sulzer competitors who have developed a customer base in the oil pipeline industry. For Sulzer the key environmental factor taking from this markets attractiveness is the markets competitive situation. The small number of customers and relatively high number of experienced competitors does not allow space in the market for new entrants like Sulzer. Furthermore, Sulzer alliance managers have indicated that many customers in this market have already established a relationship with a competitor and are happy with their solutions. Hence, it would be difficult for Sulzer to obtain a machine monitoring customer base in this industry.

Lack of technology and experience required for machine monitoring tasks in the oil pipeline industry adds resistance to market entry for Sulzer. As noted in Section 8.3, business models for Sulzer in this industry would have a heavy reliance on key partners to execute much of the required machine monitoring work. Although there are many potential companies for Sulzer to partner with, choosing key partners and building up relationships with them may take significant periods of time and further slow the market entry process.

In conclusion, pursuing machine monitoring business in the oil pipeline industry is not viewed as an attractive opportunity for Sulzer. This view is not based on business model viability, but is due to undesirable business model environmental factors.

Chapter 9

The Current ABS Wastewater Collection Control and Monitoring Business Model

9.1 Introduction

The strongest area of Sulzer Pumps machine monitoring portfolio lies in the acquired ABS wastewater control and monitoring solutions. Although these solutions are claimed to be technically competitive or superior to competitor product, the number of units sold annually is considered low. In this chapter, the ABS pump control and monitoring business model is analysed to identify areas where improvements could be made to increase profitability.

9.1.1 Objective

The main objective of the work in this chapter was to present a clear overview of the current ABS pump control and monitoring solutions business model. The purpose of the overview was to highlight the strengths and weaknesses of the current business model so that its overall functionality, efficiency and security could be evaluated. The subsequent objective of this work was to identify areas of the ABS pump control and monitoring solutions business model where improvements could be made, and to recommend how these improvements could be achieved.

9.1.2 Method

To effectively record and communicate the current ABS pump control and monitoring solutions business model, the business model canvas (see Section 4.2) was used. Details of the current business model were obtained via interviews with Sulzer staff. The majority of the information was sourced from Jörgen Jäger and Per Askenström of the ABS research and development team in Stockholm, Sweden. Other features of the business model were revealed via communication with Sulzer sales staff based at various global locations.

9.2 Customer Segments

The wastewater industry has two main segments, 1) wastewater collection and 2) wastewater treatment (Figure 9.1). Within these two segments are a broad range of customers with a variety of needs depending on the quantity and quality of wastewater they need to handle. Since the current wastewater control and monitoring offerings from Sulzer ABS are targeted at the wastewater collection segment this study will primarily focus on analysing their needs. Table 9.1 contains a summary of the customer jobs in the wastewater collection segment, and the associated pains and gains for each customer segment.

Domestic, commercial and industrial customers demand highly automated and reliable solutions as wastewater collection is not usually an important topic for them. These customers are attractive to cost effective 'set-and-forget' solutions. Municipal customers however have a high responsibility to ensure that the downstream municipal wastewater collection network is constantly functioning. This high responsibility tends to make the municipal customer segment more conservative in their solution choice, and hence large innovative changes in products and services are not often adopted well by the industry. Municipal customers also tend to have a quite restrictive budget which further promotes cost driven business rather than value driven business. Nevertheless, control and moni-

Table 9.1. Jobs of customer segments in the wastewater industry

Customer Segments	Jobs	Pains	Gains
Domestic and commercial wastewater	• To responsibly dispose of wastewater, i.e. to transfer wastewater to the municipal network for later treatment	• Unreliable wastewater removal and high maintenance requirements , e.g. frequent pump blockages • High energy bills	• Low cost solutions (purchase and installation) • Low intrusiveness, e.g. low noise, low odour
Industrial wastewater	• To responsibly dispose of wastewater, i.e. to transfer wastewater to the municipal network for later treatment • To pre-treat wastewater to required standards prior to transferring it to the municipal network	• Operating wastewater equipment as it is not critical to production • Overflows and associated fines • Equipment maintenance, e.g. tank and pump routine maintenance or repair • Energy bills • Costs of discharge flow	• Low cost solutions (purchase, installation, and maintenance) • Automated reliable solutions • Maintenance-free solutions • Low consumables costs, e.g. for treatment chemicals or spare parts • Replacement availability
Municipal wastewater collection networks	• To receive wastewater from domestic, commercial, and industrial customer segments • To transport wastewater safely and hygienically to treatment plants • To occasionally monitor wastewater quality	• Overflows and associated fines • Downtime, e.g. pump blockages, tank cleaning, pipe and seal failures • Tankering costs, e.g. for emergency pumping or sludge removal • Energy bills and carbon taxes • Changing equipment • Health and safety issues, e.g. gas control and ventilation, sulphuric acid production, cleaning tasks • Emergency calls outs	• Automated and precise leak detection • Overflow avoidance • Energy efficiency gains • Long in-system equipment lifetimes • Reliable network data collection and operation alarms • Decision making support • Maintenance planning support • Low equipment installation times • User friendly equipment

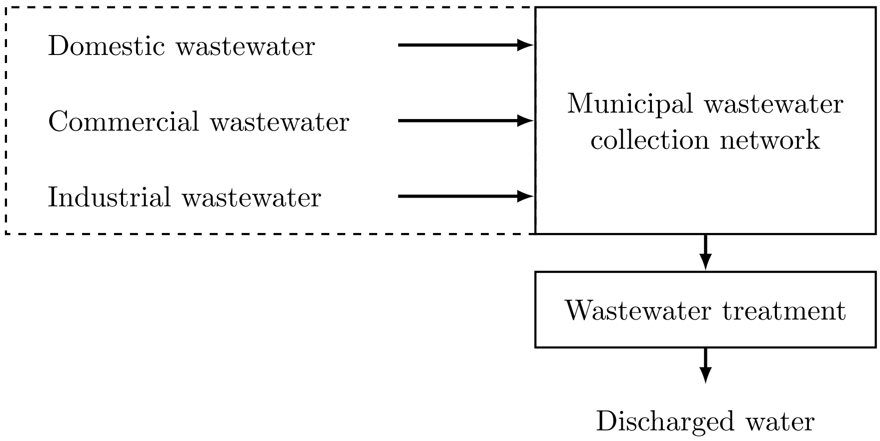


Figure 9.1. The basic value chain of the wastewater industry showing the main customer segments

toring business opportunities are most prominent in the municipal wastewater collection customer segment since wastewater collection is their sole ongoing business. Moreover, they handle large quantities of wastewater and have high responsibility to ensure that their collection network operates reliably. They also have the largest number of 'pains' where Sulzer Pumps may provide added value (Table 9.1).

The municipal waste water network can be further divided into two segments. Firstly, the replacement segment who require new equipment to replace existing but defective equipment, and secondly the 'new equipment' segment who require equipment for placement in new infrastructure. In the new equipment market, end users typically use consultants (specifiers) to specify the type of new equipment required in new infrastructure projects. Hence, the specifiers effectively become the target customers. In contrast, end users specify replacement equipment themselves in the replacement market.

Specifiers are not usually concerned with the operating costs of new infrastructure since it is outside of their job scope. Hence selling control and monitoring products to specifiers in the new equipment market has proven difficult. Instead Sulzer Pumps focuses its sales efforts in the replacement market where the benefits of ABS control and monitoring solutions, i.e. predominantly cost savings (see Section 9.4.4), may be directly conveyed to the end user. Marc Redit, head of Sulzer Pumps wastewater business development explains that Sulzer Pumps serves customers in the replacement market by firstly providing guidance with equipment selection, and secondly by providing assistance with operating their equipment. The former service is where control and monitoring equipment delivers the most value to customers.

9.3 Business Model Environment Factors

The wastewater industry trends, market forces, and industry forces mentioned in the following subsections are major external forces on the Sulzer ABS business model. Although all of these business model environment factors have a significant impact on the Sulzer ABS control and monitoring solutions business model, Sulzer head of wastewater business development, Marc Redit believes that the most important factors are in the areas of pump energy usage and pump blockage.

9.3.1 Demand for Blockage Protection

Over recent years, water shortages have caused water conservation to be heavily promoted in some areas of the world, and consequently consumers have reduced their water usage. However, customers have also demanded higher quality sanitation products, leading to more solid materials in wastewater. These two trends have resulted in the average concentration of wastewater and the average number of pump blockages to increase. Both of these issues are important drivers in the present wastewater equipment market.

9.3.2 Regulations

Sulzer head of wastewater business development, Marc Redit, believes that market demands in the wastewater industry are strongly driven by regulations. Adapting ABS solutions to future regulations before they are enforced is essential for keeping pace in the market place. Marc states that although it can be risky developing solutions for the market before they are in demand, having new solutions ready to go to market when regulations dictated a change in market demands is important to stay ahead of the competition. For wastewater collection, regulations are mainly based around overflows and energy usage.

9.3.3 Control and Communication Technology

Centralised control and monitoring systems such as SCADA systems are becoming more popular. Moreover, with expanding fibre-optic, 3G, and 4G communication networks supporting the growing popularity of tablet computers and smartphones, customers are interested in accessing monitoring system data online. These communication trends tend to provide an advantage to system integrators who specialise in specifying and configuring equipment with these technologies. Knowledge and experience in these areas are limited within Sulzer to the ABS research and development staff based in Sweden.

A customer preference towards Programmable Logic Controller (PLC) based control systems has been observed by Sulzer ABS staff. This it thought to be due to the broad range of functionality offered by PLCs. Competitors are now offering PLC functionality in their products. However, Sulzer ABS is not due to lack of development resources.

9.3.4 Competition

Many industrial control suppliers offer controls suitable for driving pumps via an electric motor and so are considered competitors. However, the added value offered in controllers specifically designed for pumps lies in built-in intelligent functions. These functions are designed specifically to optimise certain tasks (e.g. automatic blockage handling) and so these controllers are tied to application in certain industries. For Sulzer ABS control and monitoring solutions this is the wastewater collection industry. Other pump control suppliers such as Xylem, Grundfos, and KSB offer specialty pumps controllers comparable to Sulzer ABS products (see Section 9.4.3 and Appendix D for a comparison). Hence these competitors pose the largest threat for product substitution.

9.4 Value Propositions

9.4.1 ABS Control and Monitoring Product Line

Sulzer offers value to the wastewater transport industry through a variety of products under the ABS brand. Within the ABS product range, control and monitoring products are grouped into four categories:

1. Pump controllers
2. Control accessories
3. Measuring devices
4. Control panels

Each of these product lines are introduced in the following sections.

Pump controllers

The Sulzer ABS product line contains a range of pump controllers to meet the needs of customers (Table 9.2). The range starts with the PC111 and PC211 models as budget controllers for driving 1 or 2 pumps respectively. Next are the PC242 and PC441 controllers that cater for most municipal transfer stations. These controllers can drive up to 2 or 4 pumps respectively and contain more advanced and intelligent functions than the PC111 and PC211 controllers. Finally, the PCx range of pump controllers cap the end of the product line as the most sophisticated pump controller offered by Sulzer for use with up to 16 pumps. All ABS pump controllers are designed to be compatible with most competitor equipment to minimise the product switching costs on customers.

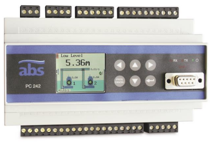
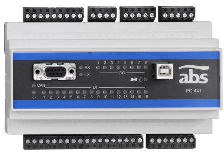
Control accessories

In addition to the pump controller product line, Sulzer offers a line of complementary control accessories such as operator panels, leakage and temperature monitoring units, and modems. These accessories are designed to connect with Sulzer ABS pump controller units.

Measuring devices

Sulzer ABS measuring devices product line contains a range of pressure sensors and level switches commonly used in the wastewater collection industry. These products are not manufactured by Sulzer, but are rebranded products.

Table 9.2. An overview of the Sulzer ABS pump controller product line

Model		Number of Pumps	Number of Pits
PC111		1	1
PC211		2	1
PC242		2	1
PC441		4	1
PCx		16	4

Control panels

Sulzer ABS offers a number of control panels which are essentially a pre-packaged set of pump control and monitoring devices with supporting electronics (Figure 9.2). These packages contain products from the pump controllers (Section 9.4.1) and control accessories (Section 9.4.1) product lines.

ABS Product Warranties

According to Jörgen Jäger, identical pump products are currently being sold in different regions with different control and monitoring requirements under the pump warranty

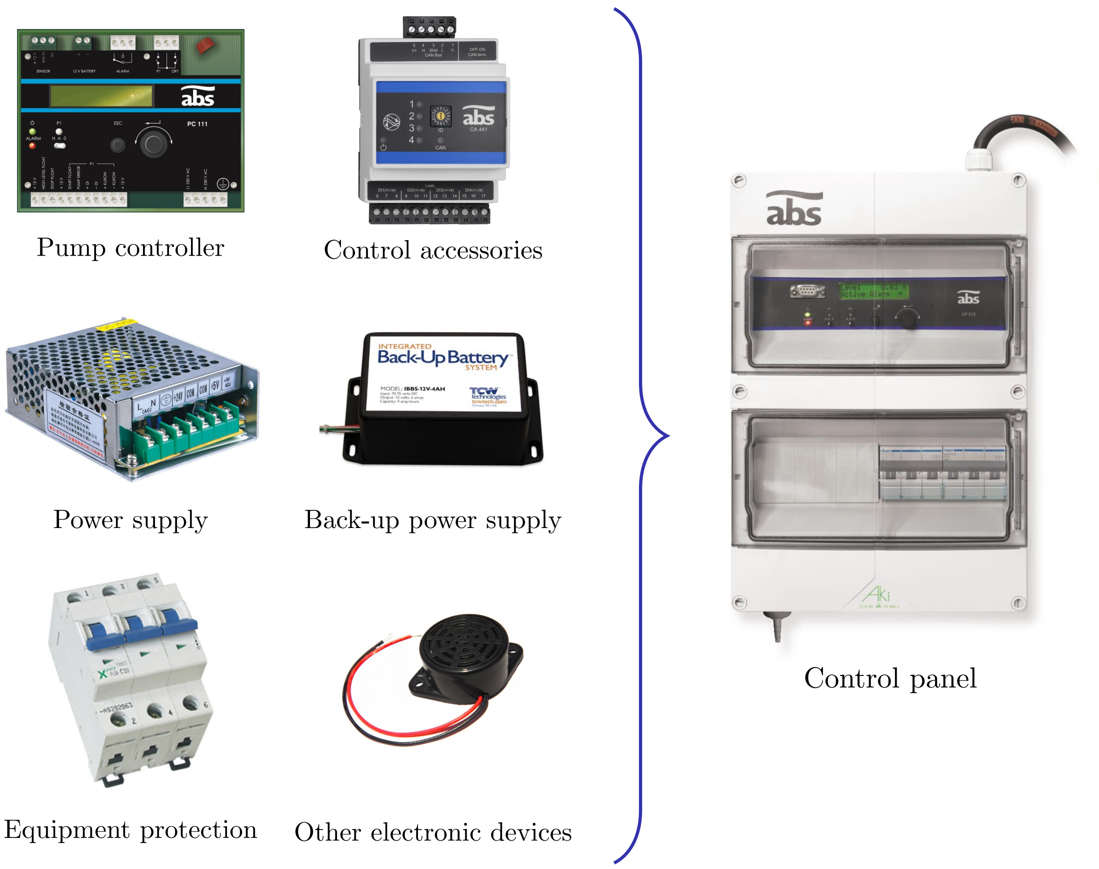


Figure 9.2. Some typical components of an ABS control panel

conditions. However, the use of control and condition monitoring products is not officially linked to pump product warranties. This is an issue that needs to be standardised throughout the Sulzer ABS wastewater product range so that consistent sales information and terms can be conveyed to customers. Making warranties conditional on the use of monitoring equipment may increase monitoring equipment sales. However, it may deter customers from using Sulzer pump products. On the other hand, competitors such as Xylem are already implementing this sales tactic according to Sulzer Sales Manager, Sam Dugan.

9.4.2 ABS Control and Monitoring Services

Sulzer offers a range of web based services to support its control and monitoring equipment. These services usually include alarm monitoring and management in combination with other features such as equipment optimisation or remote control and surveillance. Additionally, Sulzer offers consulting services for optimising customer pump operations. However, Sulzer prefers to offer these consultations free of charge as a means of generating equipment orders (see Section 9.8.6).

9.4.3 A Comparison of ABS Solutions with Competitor Solutions

Many other electronic suppliers offer competition to the Sulzer ABS pump controllers, but the most comparable products, i.e. other wastewater pump specific controller, are offered by competing global pump suppliers. The strongest competitors in this market are considered to be Xylem, Grundfos, and KSB. Table 9.3 shows how these competitors product lines compare with that of Sulzer ABS.

Xylem offers an extensive range of pump controllers including the PLC based LOGIMAC model. This is key product since Sulzer ABS and the other competitors listed previously are not producing PLC based controllers. However, Jörgen Jäger has recognised that a significant number of customers demand this type of product due to its flexibility. Grundfos offers just one specialised controller to the wastewater market. KSB offers two controllers designed for wastewater that only differ by the motor starting method (e.g.

Table 9.3. Substitute product table for Sulzer ABS wastewater transport pump controllers

	Sulzer (ABS)	Xylem (Flygt)	Grundfos	KSB
Small station	PC 111 PC 211	FGC 200 FGC 300 LOGIMAC	CU 362	DDPi DSPi
Medium station	PC 242 PC 441	APP 500 APP 700 APP 800 LOGIMAC	CU 362	DDPi DSPi
Large station/ Engineered applications	PCx		CU 362	
'No level sensor' controllers		FPC 100		
Cleaning controller	PC 242 PC 441	APF-Cleaner	CU 362	Amajet (cleaning system)

DDPi models direct online motor starting, and DSPi use start-delta motor starting). A more detailed feature comparison between the Sulzer ABS pump controllers and competitor models can be found in Appendix D. This comparison omits the latest Xylem Flygt integrated pump and process controller (APP 800) due to unavailable documentation. However, current product brochures for this controller portrait it as an industry leading product, similar in specification to the ABS PC 441 but with additional process control features.

Overall, ABS pump controllers are considered to be a very competitive offering in terms of their technical features and related customers benefits. Recent customer feedback from Steve Friendship, a Sulzer sales manager in the UK, validates this conclusion as he states that "we are far ahead of what is available in the market at the most competitive price". Hence, the value proposition is a strength of the current business model.

9.4.4 Customer Benefits

Sulzer ABS pump controllers contain as many features if not more than similar competitor products (see Appendix D product comparison). The Sulzer ABS PC 242 and PC

441 models excel in providing built-in intelligent control features to customers. However, it is not the product features that usually matter to customers, but the benefit that those feature will bring them, particularly if the benefits address one of their major pains or gains (Table 9.1). Figure 9.3 shows a list of Sulzer ABS pump controller features and how these features benefit Sulzer customers by addressing their job pains and gains.

9.5 Channels to Connect with Customers

Channels form an important part of a business model since they describe how the customer may discover and purchase the value proportion. The broader purchase process may be broken up into several stages (e.g. value awareness, evaluation, purchase, delivery, and after sales support) and it is important that the customer can complete this process easily. The following subsections present the current Sulzer ABS business model channels for each stage of the purchasing process.

9.5.1 Value Awareness

Customer discovery is the essential first step of the customer development process (see Section 4.6) used to build and sustain a business. This step involves actively seeking customers and verifying their interest in the value proposition (customer verification). Product marketing complements this process by enabling Sulzer to be discovered by customers actively seeking solutions. Hence, effective means of promoting product awareness are essential for customer base and business growth. The methods currently used to promote Sulzer ABS pump controllers are described and compared to competitor methods in the following subsections.

Internet

Many people use the internet as their first source of information and so it is very important for Sulzer Pumps to have a strong digital presence. Similar to Sulzer, all major competitors have a website. However, the accessibility of information on each competitor website varies.

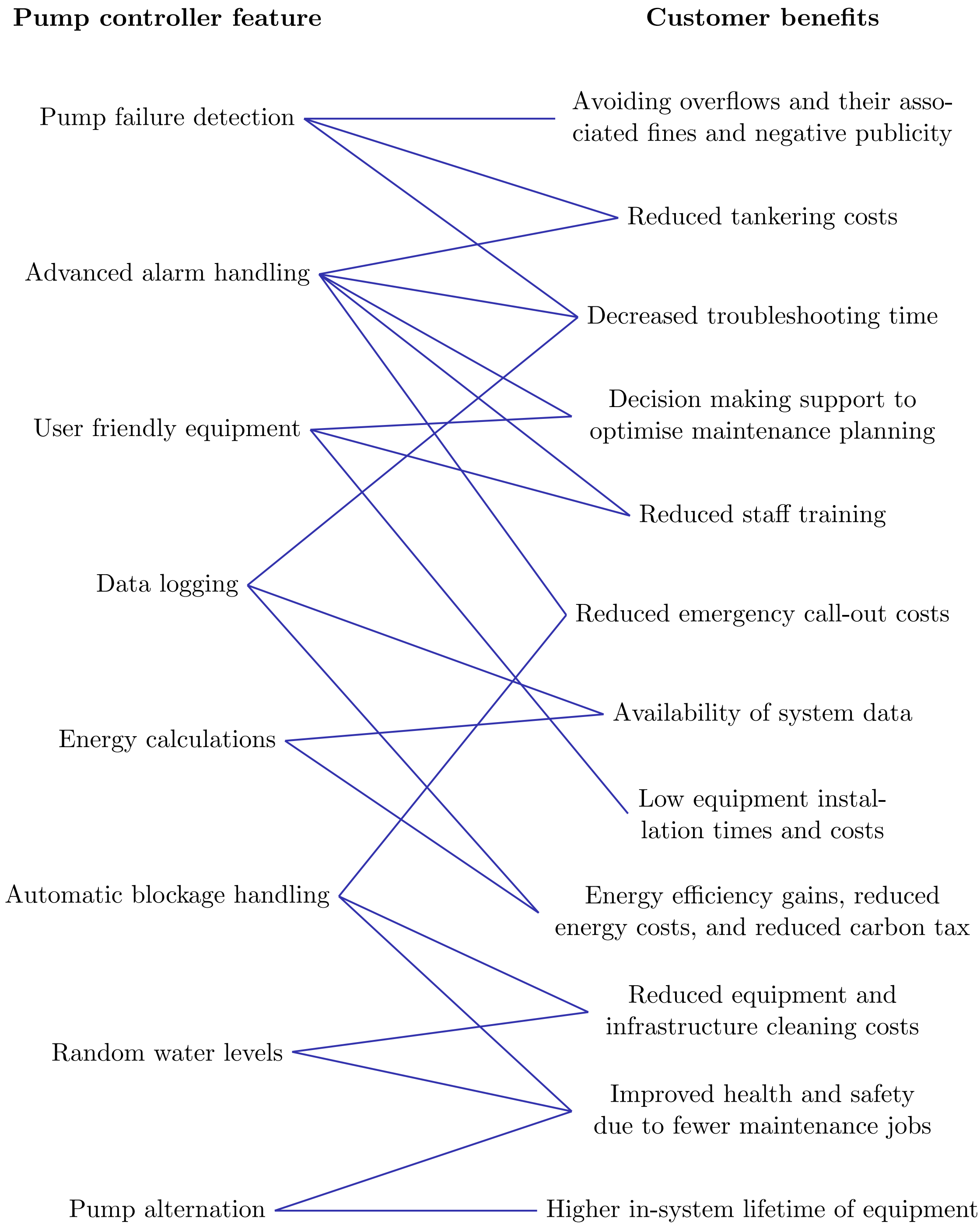


Figure 9.3. Sulzer ABS pump controllers features with corresponding customer benefits

The Sulzer website (www.sulzer.com) has a huge amount of information on it due to the many divisions, markets, and product applications which Sulzer is involved in. However, the format of this single central source of information may be quite overwhelming to customers who are simply trying to find information of one particular product. Currently selected Sulzer ABS products are still advertised on the ABS EffeX website (www.abseffex .com) which is rather simplistic in comparison. However, it is significantly easier and quicker to find particular products on this website relative to the main Sulzer website.

To compare the complexity of the Sulzer website against its competitors, the number of menu choices and selections required to navigate from the home page to the pump controller page was recorded for each company (Table 9.4). The number of navigation possibilities was also calculated, i.e. the product of menu choices and selections, to estimate the opportunities a customer has to become lost on the website without finding their product of interest. The higher this number, the higher the chance of the customer becoming frustrated and leaving the Sulzer website, or simply concluding that Sulzer does not offer solutions to meet their needs. This analysis, although simplistic, gives a rough indication to the usability of the Sulzer website with respect to competitor websites. Unfortunately the results of this analysis show that the Sulzer website has a very poor usability based on these criteria. However, the simplicity of the ABS website makes it the most functional website of those investigated.

Jörgen Jäger states that the wastewater equipment market is typically highly localised with only a small number of global players. For Sulzer to have a strong global presence it is very important that its product information and market is accessible and appealing to a range of nationalities. Table 9.5 compares the number of languages supported by Sulzer and its competitors. Notice that Sulzer offers a single global website in several languages while competitors offer a single global website with several local websites in the respective local language. This strategy may give the competition access to a larger customer base by firstly making information available in the local language, and secondly by making products more appealing through marketing tailored to the local culture.

Table 9.4. The complexity of the Sulzer website compared to that of competitors evaluated by the number of choices and selections required to find information on the wastewater pump controller product line

	Sulzer	ABS	Xylem	Grundfos	KSB
Website	sulzer.com	abseffex.com	flygt.com	grundfos.com	ksb.com
No. of selections, i.e. mouse clicks	5	1	3	2	4
No. of menu choices for each selection	3/15/13/5/5	5	7/6/32	7/20	5/3/5/12
No. of possible navigation paths, i.e. approximately the number of opportunities to get lost	14,625	5	1,344	140	900

Table 9.5. The number of languages supported by Sulzer website and various competitor

Company	Number of local websites or supported languages	Remarks
Sulzer	6 language options 1 global website	• Control and monitoring documentation is offered in 7+ languages. This is far above average for most of Sulzer Pumps products (typically 3 languages or less) • Lacking French language support
Xylem (Flygt)	40 local websites	• Local Flygt websites i.e. flygt.co.uk redirect to the local Xylem websites • Xylect interactive online catalogue is available in 5 languages
Grundfos	64 local websites	• Product documentation is consistently offered in the language of local websites
KSB	58 local websites	• 11 for online product catalogue. • Inconsistent language options for technical documentation (typically up to 5 options)

Branding

Many of competitors uses branding or trademarks to market their products and services. For example, Flygt calls their pre-programmed control routines 'SmartRun', and Grundfos calls their pressure governed water distribution control system 'Demand Driven Distribution'. In contrast, Sulzer ABS products do not use any trademarks. Jörgen Jäger mentioned that he has tried to introduce trademarks into Sulzer ABS marketing but was not allowed due to policy governing broader Sulzer marketing practices. Marc Redit, head of wastewater business development, explained that Sulzer has decided to avoid using trademarks since they are believed to dilute the main company name, i.e. Sulzer, and they are expensive to maintain. When asked if he thought trademarks would increase the attractiveness of ABS products or influence sales staff confidence, Marc stated that he did not believe trademarks would influence Sulzer ABS equipment sales.

Customer Visits

Jörgen Jäger believes that the Sulzer sales force is currently uncomfortable with approaching customers with Sulzer ABS products and services due to a lack of knowledge about these devices. This is not surprising to him as he states that only 2 or 3 sales person training sessions have been run over the last 2 years, including just one training session for U.S. sales staff. The low frequency of training sessions has been due to a lack of resources to support them.

Magazines

Information on Sulzer ABS products and services are published in the Sulzer quarterly magazine (Sulzer Technical Review) and independent magazines such as World Pumps (Sulzer Ltd, 2013c). However, Jörgen Jäger, Sulzer ABS control and monitoring product manager believes that magazine advertising is not suited to the wastewater equipment markets since market conditions vary substantially with location and there are few global magazines.

Complementary Product Advertising

Jörgen Jäger would like control and monitoring product awareness to become more integrated with pump product sales. For example, sensor amplifiers are a pump accessory that customers may be interested in to take advantage of sensors build into Sulzer pumps. However, sensor amplifiers are not currently added to pump quotes to advertise their availability and relatively small cost over the pump price. Similarly, complementary products are not advertised together on the Sulzer website. For example, an advertisement or link to sensor amplifiers would be added to the wastewater pump product pages to increase customer awareness of their existence.

Expositions

Sulzer has an exposition stand that has been used to promote Sulzer ABS products at trade expositions (Figure 9.4). ABS control and monitoring product manager, Jörgen Jäger, believes that the exhibition stand combined with descriptive presentations forms an excellent marketing combination as they provide customers with clear product information in combination with a hands-on product experience (Figure 9.5).

9.5.2 Value Evaluation

In addition to product information on the websites, Sulzer Pumps and competitors offer interactive online product catalogues (Table 9.6). For example Sulzer Pumps offers Sulzer Select, Xylem offers 'Xylect' (Figure 9.6), Grundfos offer their Web Computer Aided Product Selection tool (WebCAPS), and KSB offer EasySelect (Figure 9.7). Sulzer also offers the ABS Documentation Finder as a search tool for finding Sulzer ABS product documentation. However, this is an entirely separate tool from Sulzer Select. A more integrated product selection tool for all Sulzer Pumps products and services may improve the customer's product selection experience.

Xylect is the only interactive online catalogue previously mentioned that allows open access without registering or subscribing, which is an attractive point for users. It is also available in the five major languages of English, Spanish, French, Russian and Chi-

Figure 9.4. The Sulzer ABS display stand at the IFAT 2012 international exposition in Munich (Schiemann, 2012)

Figure 9.5. Customers interacting with Sulzer ABS control and monitoring equipment on display in exhibition stands (Jäger, 2013)

Table 9.6. Product information accessibility for Sulzer Pumps, Xylem, Grundfos, and KSB wastewater control and monitoring products

	Sulzer ABS	Xylem	Grundfos	KSB
Website	✓	✓	✓	✓
Offline electronic catalogue			WinCAPS	
Online document finder	✓			
Online interactive catalogue		Xylect	WebCAPS	EasySelect
Open access to online catalogue (i.e. no reg. req.)		✓		
Mobile app catalogue		Xylect Mobile	AppCAPS/ Grundfos Go	

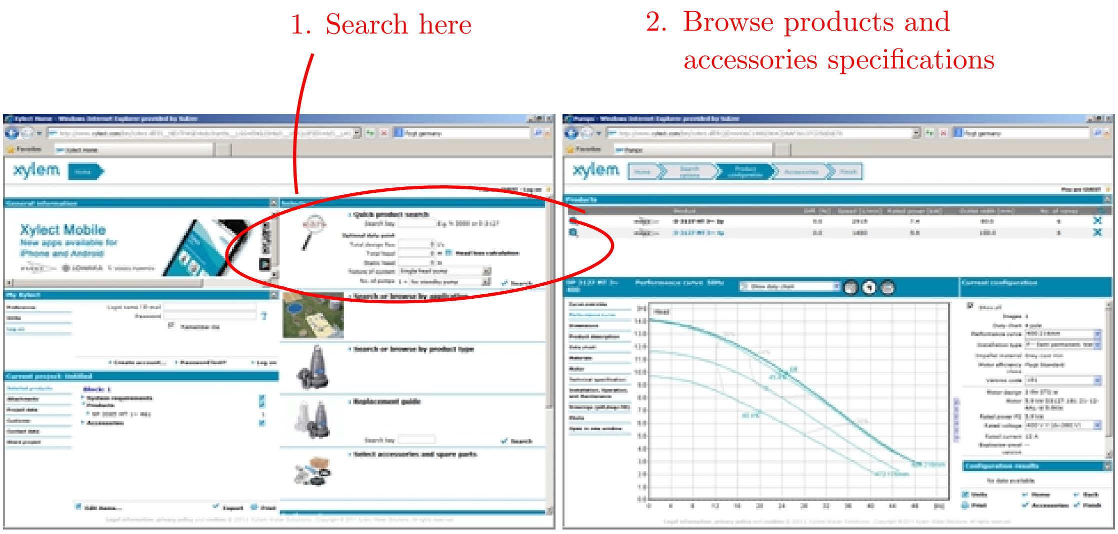


Figure 9.6. Screenshots of the Xylect interactive catalogues viewed with Microsoft Internet Explorer. Home page of the catalogue (left) and the product configuration page (right) showing technical data including pump performance curves

nese. Customers who wish to use Sulzer Select must first complete an online registration form before access is approved by their local Sulzer sales and marketing team. Thomas Sendelbach currently manages the Sulzer Select tool and states that the purpose of the registration and login procedure is used to manage who uses Sulzer Select. It is used to limit competitor access to Sulzer Product information and to limit potential spam emails to Sulzer marketing teams.

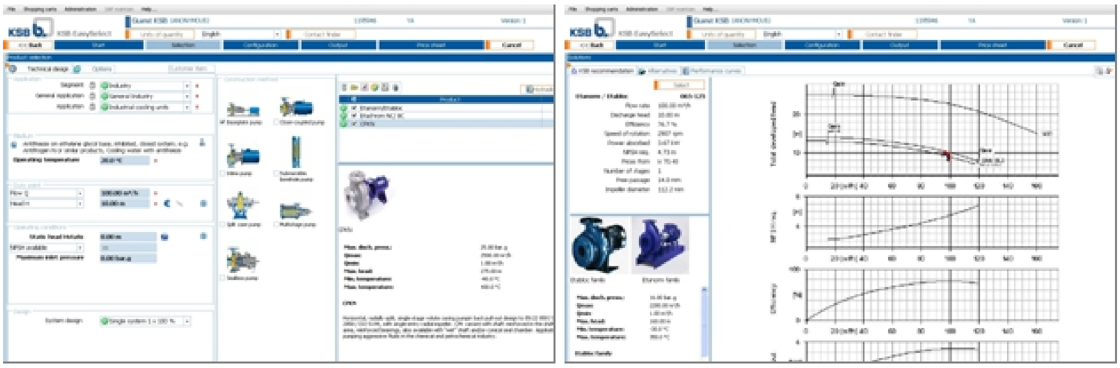


Figure 9.7. Screenshots of the KSB EasySelect Online catalogue

In addition to web browser access, Xylem also offers dedicated applications for accessing their Xylect product selection tool on iOS and Android platforms. Similarly, Grundfos offers access to their product catalogue through their WinCAPS PC application and their AppCAPS of 'Grundfos Go' mobile application.

Although these catalogues allow customers to easily select the most appropriate product for their needs based on the product specifications, they do not help the customer to evaluate the value or benefit of the products, which is usually a financial benefit (see Figure 9.3). Sulzer can provide cost saving estimates by conducting energy audits (see Section 3.10) or by consulting with the four-step process (see Section 9.8.6). However, both of these processes require Sulzer staff to evaluate customer equipment and operations. Offering a means for customers to independently evaluate their own equipment and operations via a tool that links them to Sulzer product information may increase sales while decreasing sales staff work loads.

9.5.3 Purchasing, Delivery, and Installation

Customers may purchase Sulzer ABS control products through their local Sulzer sales office and arrange for delivery and installation. ABS control and monitoring product are also available through some panel vendors which chose to use Sulzer ABS devices. Once installed, ABS controllers may be configured by the end user or they may be configured remotely by Sulzer technicians.

9.5.4 After Sales Support

Sulzer Pumps provides after sales technical support to its ABS customers through their local sales offices. Customers must first approach their local sales consultant who will then either resolve the customer problem, or consult with technical support staff in Sweden. For issues outside of normal installation support or warranty claims customer support services are often free or charge. However, customers are charged for additional technical support from the Swedish office.

9.6 Customer Relationships

Sulzer interacts with customers interested in ABS control and monitoring solutions through its sales staff around the world. Sales staff trained specifically for selling ABS control and monitoring products are based in Sweden, Spain, Italy, the U.S., and Germany. In addition to handling equipment sales, sales staff are also the first point of contact for customer requesting after sales support.

Sales staff work with the customer to identify their needs and may use the Sulzer ABS 'four-step process' (see Section 9.8.6) to aid with this task. Marc Redit and Jörgen Jäger confirmed that it is not normal for sales staff to follow up with customers after equipment sales. Instead sales staff wait to be approached by the customer. This approach to customer service was apparent in the CSS and sales staff survey results (Chapter 5) as several with written responses indicated a lack of proactive engagement with customers. For example "they (customers) haven't asked" or "customers do not generally bring this up".

9.7 Revenue Streams

Revenues in the Sulzer ABS control and monitoring business model are generated primarily through product sales. However, revenue is also generated through customer technical support services charges and monitoring service fees. In 2012 annual sales for Sulzer ABS control and monitoring products and services equated to 3.2m CHF.

Although revenue generated through pump control and monitoring equipment sales are negligible for Sulzer Pumps compared to that generated through pump sales, customer using condition monitoring equipment will be more aware of their operation inefficiencies and therefore more likely to purchase pump products to improve their operations. Hence selling and supporting condition monitoring equipment may have a catalytic effect on pump sales. Recognising this effect, the value of Sulzer Pumps control and monitoring business should include pump sale revenues generated in this way.

9.8 Key Activities

9.8.1 Research and Development

Technological research and development of the Sulzer ABS control and monitoring product line is done by three engineers based in Sweden. In addition to research and development tasks these engineers are also responsible for supporting production issues and providing customers with technical support. Jörgen Jäger notes that one hindrance to customer driven developments is that technical staff in Sweden have difficulties obtaining feedback from sales staff abroad since the sales staff are typically very busy. This resistance to feedback may hinder value driven product development and innovation (Figure 9.8).

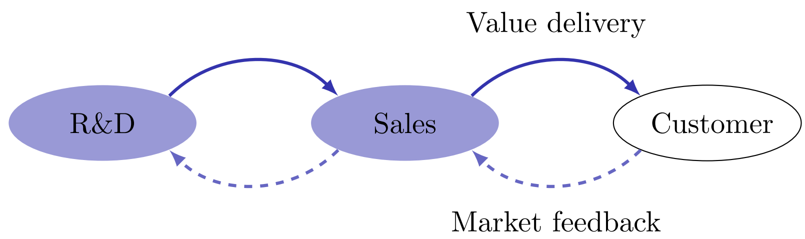


Figure 9.8. Weak communication between departments may suppress market feedback and hinder product innovation and development

9.8.2 Production

Production of Sulzer ABS pump controller hardware is outsourced to the key partners mentioned in Section 9.10. While Sulzer ABS pump controllers are manufactured and assembled in Poland, Sulzer technical support staff in Sweden are involved with setting up production and solving production issues. Sensor hardware is not produced by Sulzer, but is purchased from sensor manufacturers and rebranded as being a Sulzer ABS product. This is not considered a secure business model, since customers may purchase identical sensors from the manufacturer at a lower price than Sulzer sells them for.

9.8.3 Documentation

Documentation for Sulzer ABS products such as technical data sheets, user guides, and staff training material are produced in Sweden. Jörgen Jäger, ABS control and monitoring product manager, creates the technical documents to accompany the product line while other graphic design staff create product brochures and marketing material in accordance to the Sulzer marketing style.

9.8.4 Storage and Distribution

Coordinating logistics around Sulzer ABS pump controller products is handled by Sulzer Pumps Ireland. The logistics company Kuehne + Nagel is employed to store and transport pumps controller products.

9.8.5 Sales and Marketing

Sulzer uses its sales staff as a first point on contact for customers. They are responsible for handling customer inquiries, purchase orders, technical assistance requests, and any other requests the customer may have. Hence, since the customer has a large degree of interaction with Sulzer sales staff it is very important that these staff members convey a good impression of Sulzer to customers. Moreover, they are an essential link in the chain of communications for providing Sulzer research and development staff with customer feedback (Figure 9.8). Unfortunately, many Sulzer sales staff are uncomfortable with discussing control and monitoring product with customers, approximately 90 % according to Marc Redit. This is firstly due to many sales staff having a mechanical engineering background, rather than a controls, information technology, or electrical engineering background, and secondly due to a lack of training with Sulzer control and monitoring solutions.

Jörgen Jäger, Sulzer ABS control and monitoring product manager is convinced that staff confidence could be increased via better training and is frustrated that only 2 or 3 sales staff training sessions have be run over the last 2 years. Sales staff also agree that a lack of training and support is a contributing factor to low sales figures. Daniel Snchez is an experienced Sulzer sales person and control panel designer with a good knowledge of Sulzer control and monitoring products. Daniel has the same view as Jörgen and states that finding good sales staff and technicians to support control and monitoring business is difficult. Kevin Sparks, a Sulzer sales engineer, also has first hand experience selling ABS control and monitoring products and also believes that sales staff do not receive adequate training.

9.8.6 Consultations

The four-step process (Figure 9.9) is a sales consulting structure developed by Marc Redit and Jörgen Jäger. It is designed to increase customer awareness of the benefits of machine monitoring and to guide them through the equipment selection process. Step one involves surveying the customer site and assessing pump performance. Next, step 2 entails using the survey results to create a business case that proposes cost savings to the customer. Once a plan of action has been agreed upon with the customer, step 3 involves delivering and installing the hardware required by the customer and training staff. Finally, in step four, measurements are taken to validate that the upgraded equipment is producing the cost savings estimated in step 3. After this point the four-step process may start again to further improve the customers pumping operations.

Sulzer sales staff currently use the four-step process as a sales tool when approaching end users. Marc Redit states that these consultations are usually free of charge for the customer. However, Sulzer occasionally provides these consultations as a paid service. A third type of transaction in which the four-step process is used is in a 'pain-gain share' type situation where Sulzer halves the cost of the consultation and the equipment costs with the customer in exchange for half of the resulting savings the customer benefits from. Overall, Marc Redit advises that it is preferred that Sulzer offers consultations for free as it gives Sulzer an edge over the competition when trying to acquire orders.

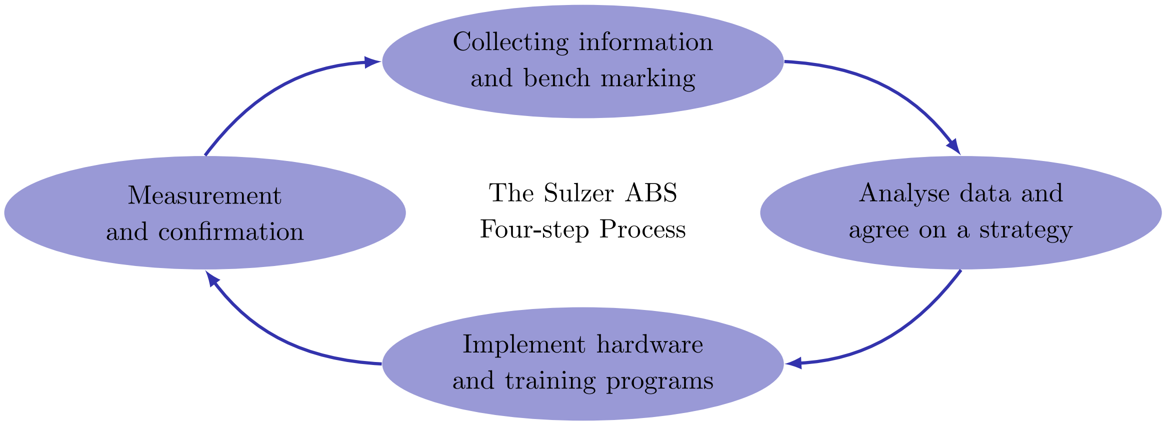


Figure 9.9. The Sulzer ABS four-step process

Marc Redit states that Sulzer competitors have tried similar consulting techniques. However, the four-step process has not been equalled yet. One feature that makes four-step process consultations unique is that it is supported by web based software for analysing customer operations and estimating potential cost savings. This software is part of the ABS AquaWeb software package, but is not available for customers to use independently of Sulzer.

9.8.7 Customer Technical Support

Sulzer sales and technical staff are responsible for providing after sales support services (see Section 9.5.4). Customer requests for technical support are usually handled by local Sulzer sales staff who redirect complex technical support issues to technical staff based in Sweden if required.

9.9 Key Resources

9.9.1 Human Resources

Technical staff assigned to control and monitoring activities include three engineers and two technical support staff who develop and maintain the current product line, and one product manager who monitors sales and development activities. Jörgen Jäger, ABS control and monitoring product manager, estimates that approximately 70 % of the engineering staff time is spent on technical support tasks including production support and customer service support. This means that only minimal research and development tasks are able to be completed. However, Jörgen Jäger also states that there is not enough funding to employ more staff.

Sulzer has general sales staff based at various locations around the world who market both the pumps and control and monitoring product line to customers. Although Sulzer employs many sales staff, Marc Redit estimated that 90 % are not comfortable with selling control and monitoring products since they are usually from a mechanical engineering background rather than an electrical engineering or information technology background. Both Marc Redit and Jörgen Jäger believe that the lack of confident sales staff is a significant factor contributing to poor control and monitoring product sales figures.

9.9.2 Physical Resources

Research and development of Sulzer ABS pump controllers requires various equipment including computers, testing panels, and other electronic devices. Research and development staff also require laboratory and offices space to use and store their equipment. Currently all research and development assets are located in Stockholm, Sweden.

To host monitoring services utilising the ABS AquaWeb software Sulzer must maintain a central server. Currently there is one AquaWeb server in Sweden which serves all AquaWeb clients. However, Jörgen Jäger stated that if demand for monitoring services increase in the U.S. this may warrant another server being setup.

Physical resources used to produce Sulzer ABS control and monitoring products (e.g. tooling) were manufactured and used by Fideltronik, Sulzer's key partner for manufacturing ABS control and monitoring electronics (see Section 9.10). According to Jörgen Jäger, Sulzer has just recently purchased these resources from Fideltronik.

9.9.3 Financial Resources

The yearly budget for ABS control and monitoring business is now integrated into the central Sulzer budget, where the budget for each year is based on the budget of the previous year. Jörgen Jäger stated that although the 'control and monitoring handling budget' is intended for research and development, the majority of this budget goes towards maintaining and producing the control and monitoring product line. He believes that this is not sustainable long term since it does not allow for development tasks to get the funding they require.

9.9.4 Other Resources

Sulzer has so far maintained the ABS brand after acquiring Cardo Flow Solutions. This action is considered neither beneficial nor detrimental to Sulzer wastewater control and monitoring business since Jörgen Jäger states that the ABS brand has a high reputation in some regions while having a poor reputation in other. As mentioned in Section 9.5.1, Sulzer generally does not support branding of its products and it is undecided if the ABS brand will be maintained in the future.

9.10 Key Partners

Sulzer relies on several key partners to maintain its ABS pump control and monitoring business. Firstly, research and development tasks rely on software from Microsoft and IAR for embedded software developments. Secondly, production of the ABS pump controller hardware is done via electronics manufacturing services provided by Fideltronik, Poland. Components for production are simply sourced from the best supplier at the time. Similarly, electronics cases are sourced from various suppliers depending on the product series. Thirdly, development of the ABS AquaWeb software was outsourced to AdHoc software developers in Sweden. Other software developments are done in-house by Sulzer ABS research and development engineers. Finally, GPRS communications are handled by Telenor in Sweden, while IPeer provide a server to support AquaWeb. In the U.S. AT&T are considered as a preliminary partner for hosting GPRS communications.

9.11 Cost Structure

Since manufacturing of ABS pump control and monitoring product is outsourced, Sulzer does not see details of the manufacturing costs. Instead Sulzer is concerned with the unit cost at which each product is purchased for from the manufacture. As products are brought to the market through Sulzer sales companies additional costs are incurred, such as administrative costs, marketing expenses, logistics cost, and other overhead costs. In addition to costs associated with product sales, the ABS business model contains costs associated with hosting its web based monitoring services. Major costs for providing these services include the web hosting service charges, and charges for GPRS communications. Research and development activities come with costs to purchase items such as laboratory equipment, prototyping materials, and other testing devices. These expenses are covered by the research and development budget assigned to the ABS control and monitoring team. However, as mentioned in Section 9.9.3, in reality the majority of this budget goes towards maintaining production operations. Overall, the total costs for the ABS control and monitoring business equate to approximately 1.3m CHF annually (based on the 2012 profit and loss account).

9.12 Evaluation of Current Business Model

The Sulzer ABS control and monitoring business model details mentioned in the previous sections have been summarised in the business model canvas shown as Figure 9.10. The business model environment around this model is shown in Figure 9.11. These figure provide an overview of how the ABS control and monitoring business functions. In this section the ABS business model design is evaluated to identify areas where it could be improved.

Amit and Zott (2012) suggest that business model innovation is driven by four major factors; novelty, lock-in, complementarities, and efficiency. Each of these traits has been used to evaluate the ABS control and monitoring business model in Sections 9.12.1 to 9.12.4. In addition, the non-financial returns from the current business model are mentioned in Section 9.12.6 and the current customer development efforts are noted in Section

Key Partners

- GPRS network carriers:
  1. Telenor
  2. AT&T, Preliminary US partner
- Electronics partners:
  1. Manufacturing: Fideltronic (Poland)
  2. Components: Best fit in each project
- Electronics casing manufacturer varies between product series
- Software developers:
  1. AdHoc for AquaWeb
  2. The rest is done in house
- Vendors:
  1. IAR (Embedded), Microsoft (PC)
- Hosting of web based monitoring tools:
  1. Ipeer
- Logistics:
  1. Kuehne + Nagel

Key Activities

- Ongoing R&D
  - New features & enhancement of existing products
  - Simple monitoring relays (high volume)
  - Definition of next generation monitoring & equipment control
- Training of sales people (rare)
- Sales visits /Technical support
- General administration

Key Resources

- R&D staff at Sulzer WWS
- Sulzer sales people
- ABS brand is OK in some areas, poor in others but slowly starting to improve
- R&D funding is mainly sourced through the central budget. However, occasionally minor customer projects contribute
- Server for hosting web services; AquaWeb and 4-step Process solutions
- No patents

Value Proposition

- Intelligent waste water pump control and monitoring solution
  - Reduced maintenance
  - Pump protection
  - Energy savings
  - Reduced overflow events
  - Reducing cleaning requirements
  - Lower tankering costs
- Web based monitoring
  - 24 hour equipment supervision
  - Automated alarm handling and remote communication of alarms: reduced call out costs

Customer Relationship

- Personal ordering/sales assistance
- Customers approach Sulzer for sales/technical assistance
- Personal basic technical assistance, or advance technical assistance via phone or email
- Sulzer gets customer feedback via sales staff

Channels

- Personal sales visits to engineering consultants to advertise the controllers
- Presentations with a portable controller are used to demonstrate controller feature to customers

Customer Segments

- Municipalities (end users)
- Engineering, construction and procurement contractors (specifiers)

Cost Structure

- Production setup cost + component purchase costs+ cost per unit built + logistics and shipping costs
- Marketing costs are absorbed by Sulzer central budget
- Web hosting costs. These are 25k SEK (~1.8k CHF) annually
- GPRS communication costs
- Ongoing R&D costs. The 2013 budget is for 5.9m SEK (~410k CHF) including tech support and AquaWeb operations and maintenance

Revenue Streams

- Sale of controllers
- Service fees for AquaWeb (communication hardware rental + communication fees)
- Technical support service fees

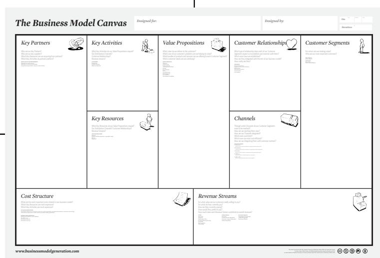
Figure 9.10. The business model canvas for ABS pump control and monitoring solution

Industry Forces

- Many companies are offering generic pump controllers
- Some pump manufacturers are offering specialised pump controllers for the wastewater industry. These companies are Sulzer's biggest competitors
- EPC companies have a strong hold on the new equipment market. Direct end users sales are typically for replacement equipment

Market Forces

- Customers demand pumps and controller that can handle blockages
- End user customers demand energy efficiency to reduce their electricity costs
- As wastewater concentration rises pumping equipment must be sufficiently resistant to more aggressive pH levels
- Customer demand for PLC type controllers is still strong since they are perceived as cheap and versatile



Key Trends

- Increasing blockages: Consumers using less water (for water conservation) while using higher quality sanitation products
- Communication technology: The popularity of remote sensing and centralised control systems is increasing
- Increasing quantities of legislation: Current and future legislations will dictate acceptable levels of energy consumption for pumps and other equipment

Macro-Economic Forces

- In 2004 approximately 41 % of the world population did not have access to improved sanitation facilities (World Health Organisation, 2006). This has reduced to 15 % in 2013, but it still an ongoing world issue (United Nations, 2013a)
- Water and energy conservation is becoming increasingly important as the world population increases

Figure 9.11. The business model environment for ABS pump control and monitoring solution

9.12.7.

9.12.1 Novelty

The current Sulzer ABS business model arguably has a low degree of novelty. The majority of key activities are executed in a 'standard' or 'normal' manner, i.e. key activities are done in the same way as equivalent activities are done in many other companies. The exception to this observation is consultations that use the four-step process (Section 9.8.6). Although competitors have tried to provide equivalent consultations, Marc Redit states that they have not been successful since Sulzer consultations using the four-step process utilise ABS AquaWeb software which competitors do not have.

9.12.2 Lock-in

Lock-in refers to elements of a business model which prevent customers from discontinuing their participation. A common means locking-in customers is to ensure that they have a high switching cost once participating in the business model. Currently there are no elements of the ABS control and monitoring business model that feature lock-in strategies. However, Sulzer ABS products have been designed to be compatible with many competitor products in order to prevent customers from being locked-out.

9.12.3 Complementarities

In terms of business model innovation, complementarities refer to dependencies between business models that generate a value-enhancing effect. For example, by offering machine monitoring solutions that inform customers when they require spare parts or new equipment, Sulzer may acquire extra pump and spare part sales. These equipment sales are only possible due to machine monitoring business stimulating the market. However, these sales are never recorded in the machine monitoring business sales records, and hence the machine monitoring businesses profitability figures do not benefit from these transactions. Jörgen Jäger believes that this devaluing effect on machine monitoring business is active within Sulzer and estimates that almost 50 % of control and monitoring turnover is hidden within pump sales.

Gaining perspective on the true value of machine monitoring business, including the value of its complementary effects is a difficult task. Jörgen Jäger stated that the value of complementary effects was estimated approximately three years ago. However, Marc Redit confirmed that there is no remaining record of this analysis. Currently Sulzer does not have a means of quantifying the complementary effects that its machine monitoring business has on its pump equipment sales. However, it is recommended that such a method be derived in the near future to allow for a fair evaluation of machine monitoring business contributions.

9.12.4 Efficiency

Amit and Zott (2012) suggest that the efficiency of a business model is related to cost savings through inter-connection of key activities. Under this definition the ABS control and monitoring business model has a low efficiency due to its key activities being decentralised and relatively independent of each other, and its price transfer system creating unnecessary costs. For example, Jörgen Jäger has realised that the price transfer model used by Sulzer (see Section 9.12.5) increases the unit cost by at least two factors (e.g. u-price factor and h-price factor which are country dependent) leading to excessive market prices for Sulzer ABS control and monitoring products. Poor communication between sales and development staff also decreases the business model efficiency since it causes market feedback processes to be time consuming (Figure 9.8). ABS logistic activities are also considered inefficient since inventory storage facilities are located in a different country than production facilities which incurs extra freight costs.

9.12.5 Profitability

To calculate the ABS control and monitoring business profitability it is important to have the correct sales figures and to understand the internal price transfer system. As shown in Figure 9.12, several different prices are placed on a product as it is transferred from Sulzer Pumps manufacturing units to the market place. These different prices may be calculated with Equations 9.1 to 9.3 given the price factors which vary with country. However, to calculate internal profit only the unit cost and the market price need to be known.

$$\text{U-price} = \text{Unit cost} \times \text{U-price factor} \tag{9.1}$$

$$\text{M-price} = \text{U-price} \times \text{M-price factor} \tag{9.2}$$

$$\text{H-price} = \text{U-price} \times \text{H-price factor} \tag{9.3}$$

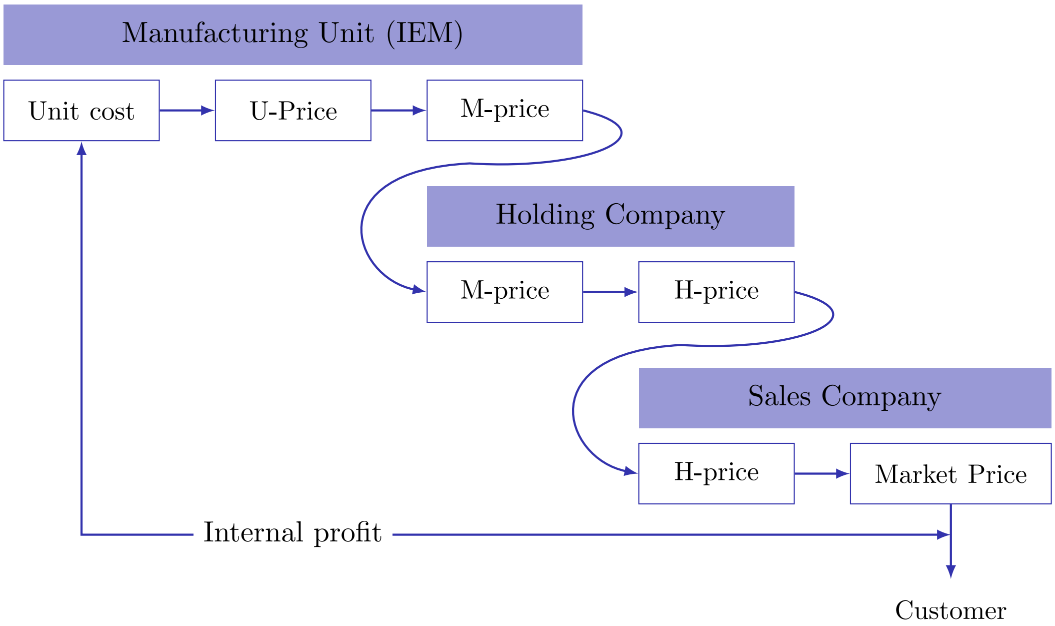


Figure 9.12. Sulzer internal price transfer system (*Source: Ton Vrenegoor*)

Fortunately the total net sales at market price are recorded on the Cardo Flow Solutions control and monitoring profit and loss sheet along with the total costs of goods sold including internal costs at Sulzer (see Section 9.7 and Section 9.11 respectively for 2012 figures). These two figures can be used to calculate the gross profit margin for ABS control and monitoring business using Equation 9.4, which was 60.5 % in 2012, almost double that of Sulzer Company (31.0 %) (Sulzer Ltd, 2013a).

$$\text{Profit margin} = \frac{\text{Net sales} - \text{Costs}}{\text{Net sales}} \tag{9.4}$$

Calculating the profitability of the business model is recommended to verify its design. However, to calculate a fair profitability figure for the ABS control and monitoring business, the value of complementary effects associated with the business model should be included. But, as mentioned in Section 9.12.3 quantifying these effects may be difficult.

9.12.6 Non Financial Returns of Control and Monitoring Business

Complementary pump and spare part sales generated through machine monitoring business, as described in Section 9.12.3, are examples of financial value added to Sulzer that are not accounted for in the financial records of the machine monitoring business. Similarly, machine monitoring business may also generate value for Sulzer that does not have an easily quantifiable financial value. For example, data captured via Sulzer ABS machine monitoring devices may provide Sulzer with significant insight into how Sulzer pumps are operated by the end user. Feedback such as this could be available through channels other than Sales staff (addressing the feedback bottleneck in Figure 9.8) and could be very useful for research and development tasks.

Similar to complementary business (see Section 9.12.3), it is difficult to quantify the non-financial or intangible benefits of machine monitoring business in monetary terms. However, it is important that these effects are accounted for when evaluating the business models profitability.

9.12.7 Customer Development

Currently the ABS control and monitoring business model predominantly relies on customers to discover Sulzer ABS solutions independently, and for Sulzer sales staff to provide customer validation. This reactive approach to customer discovery, as described in Section 9.6, may significantly limit the business customer base size. Moreover, proactive customer discovery processes are considered limited due to sales staff lacking the confidence with ABS control and monitoring products to actively promote the products.

9.13 Suggested Improvements for the ABS Business

In this section, several methods for improving the Sulzer ABS control and monitoring business model are suggested. These suggestions address many of business model weaknesses mentioned in Section 9.12, but are not a comprehensive list of development options. Also note that these suggestions are merely concepts for business model development and should be thoroughly evaluated before being incorporated into the current business model.

9.13.1 Focus on Channels to Connect with Customers

Channels used to connect with customers and a description of typical customer relationships were described in Section 9.5 and Section 9.6 respectively. These findings pointed out that Sulzer has a relatively weak digital presences and a limited personal presence in the market place. The following subsections contain suggestions on how Sulzer could improve its offerings in these areas.

Improved Marketing

Currently Sulzer ABS products are marketed with a focus on product features. These are often engineering specifications that may or may not have any meaning to potential customers. A better way of marketing is to point out product benefits that will appeal to target customers (see Figure 9.3). Sulzer sales engineer, Robert Santiso Vazquez , has significant experience in selling ABS pumps controllers to end users and agrees that "from the marketing point of view, (we need to) try to concentrate more on the functionalities of the (ABS pump control and monitoring) equipment, rather than on technical details."

Marketing could also be improved by strengthening the link between Sulzer pump products and Sulzer ABS control and monitoring products. Currently marketing for these two product groups is quite independent and does not promote the benefits of their combined use. This situation could be improved by adding advertising for control and monitoring equipment adjacent to pump product information. This could be done on the Sulzer website (Figure 9.13), in product brochures, in technical documentation (e.g. expressing product compatibility), and within existing product selection tools.

Improving Digital Tools

Sulzer Select Product Selection Tool

As mentioned in Section 9.5.1, Sulzer hosts the online interactive product selection tool Sulzer Select. Integrating Sulzer ABS products into this tool or offering a similar tool for ABS branded products would be a means of providing computer aided product selection guidance and direction towards the appropriate documentation. As a result, Sulzer could expect more customers viewing ABS branded products with a reduced load on sales staff.

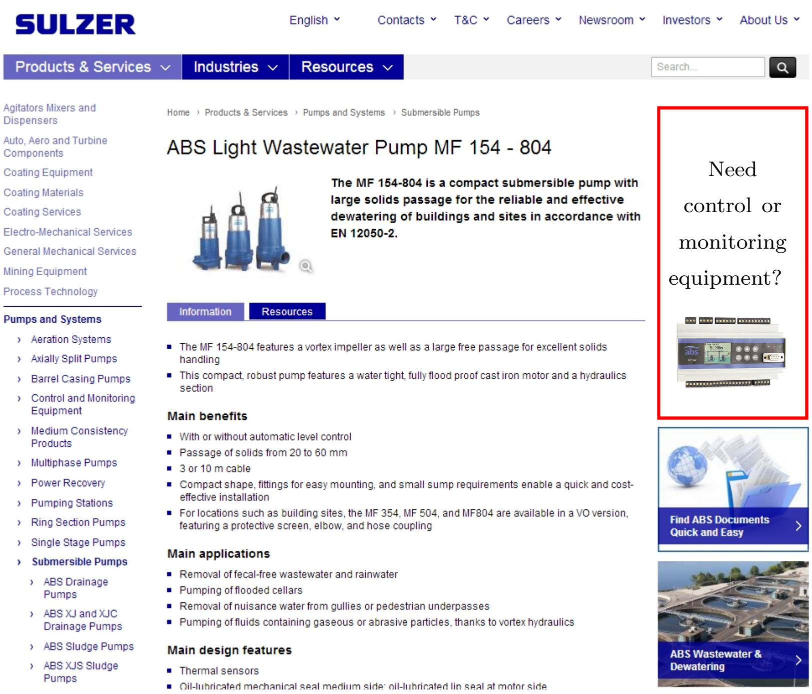


Figure 9.13. Advertising Sulzer ABS control and monitoring equipment alongside pump product information (red box) may increase customer awareness of control and monitoring products, and the benefits of combining them with pump equipment

To further improve this service Sulzer should consider making this tool open access, i.e. able to be used without customers being required to register or create an account. Although extra digital security measures may have to be considered, this would reduce resistance to customers viewing Sulzer products by creating an 'open door' impression of Sulzer. Small changes such as this may be very important for improving the Sulzer ABS customer discovery rate.

PumpsOnline Product Selection and Ordering Tools

In 1999 Sulzer Pumps' began providing the web based tool called 'PumpsOnline' (Metsola, 2003). This extranet solution allowed customers to order spare parts, review Sulzer Pumps product documentation and marketing material, and register their Sulzer Pumps install base. Initially the PumpsOnline was built on Sulzer Pumps' enterprise resource planning (ERP) system and comprised three components: PartsOnline, Document Library, and

Installed Base Management. Since then it has been modified for compatibility reasons when Sulzer Pumps adopted the SAP ERP system. Now, PartsOnline and Installed Base Management have been superseded by WebShop and Asset Management respectively (still within PumpsOnline), and Document Library has been separated from PumpsOnline and renamed DocsOnline.

Presently, the WebShop component of PumpsOnline is in full use in North America allowing distributors to place spare part orders with the Parts Processing Centre in Easley, South Carolina. Other components of PumpsOnline are not currently fully utilised due to system related issues. Pekka Salmi stated the Process Pumps have plans to upgrade PumpsOnline in order to restore its full functionality. However, there is currently no development activity on this project due to the cost of the project. Nevertheless, updating the PumpsOnline tool could be a means of building stronger connections with customers.

Increasing Sales Staff Confidence

As mentioned in Section 9.6, Sulzer interacts with its customers predominantly through its sales and CSS staff. Hence, it is essential that these staff can proactively serve Sulzer customers with excellent knowledge of Sulzer products. This point has also been stressed by the Sulzer Chief Executive Officer, Klaus Stahlmann, in a recent interview when he stated that "the sales teams must understand the customer requirements and the Sulzer offerings in the new areas, and not least, they have to share their technical expertise" (Sulzer Ltd, 2013d). Moreover, sales staff agree that they have insufficient training to confidently sell control and monitoring equipment. For example, when contacted regarding recent sales experiences, Sales Engineer Kevin Sparks explicitly stated that he believes he has not received enough training and sales information to confidently sell ABS pump controllers. Kevin also said that "the brief training we received did not prepare us for the finer details of the setup, commissioning and troubleshooting (with the ABS PC441 pump controller)". Increasing sales staff confidence through adequate training programs may improve sales and customer services while also improving the customer views of Sulzer as a competent control and monitoring equipment and services provider.

Opening Feedback Channels

As shown in Figure 9.8, channels of communication between customer and Sulzer research and development staff are restricted and have a bias in direction toward the market. This significantly limits market feedback, and hence product and business model innovation potential at Sulzer. Digital communication methods now provide businesses with the opportunity to invent novel and customised means of market data collection and communication with their customer bases without large ongoing costs. Hence, it is suggested that Sulzer Pumps integrates customer feedback tools into its digital communication programs.

Improving Lock-in

Lock-in features could be integrated into the ABS control and monitoring business model to encourage customer loyalty. For example, linking the validity of Sulzer pump warranties to the use of machine monitoring equipment would encourage Sulzer pump customers to also purchase condition monitoring equipment. Another example might be increasing the dependence of ABS monitoring devices on web services. In this case customers who purchase ABS monitoring equipment would be more likely to purchase online services to maximise the potential of their equipment

9.13.2 Changes for Key Activities

Amit and Zott (2012) suggest that innovative changes to a business model can be done through modifying key activities (see Section 4.7.1). Moreover, they suggest that modifications can be categorised as targeting the key activity content, structure, or governance. For the current ABS control and monitoring business model it is suggested that sales staff training activities be revised since the present lack of sales staff training impacts both revenue streams and customer relationships.

To address this issue, it is suggested that sales staff training sessions occur more frequently, and involve more sales staff without restrictions on sales branch region. Firstly, this could be achieved by hosting online training sessions which would be an example of new key activity content. Secondly, to support these training sessions, additional internal product documentation could be created for educational purposes. Furthermore, integrating the creation of these internal training documents with the creation of existing product documentation would represent a change in the structure of these documentation activities. Thirdly, key activity governance could be modified by employing a product training manager to organise product training sessions, create educational documentation, and to ensure the overall effectiveness of sales staff training programs.

9.13.3 Modifying the Value Proposition

Modernising the physical design of the ABS pump controller range with touch screens would be a small modification to the ABS value proposition for increasing product attractiveness and usability, while potentially reducing the product cost. Touch screens are now standard in many modern devices such as mobile phones, mp3 players, and portable computers because the often make devices more intuitive to use and more appealing to a broader customer audience. Similarly, they could also increase the appeal of ABS pump controllers by giving them a cleaner, more modern user interface. In addition, eliminating mechanical buttons on the pump controllers may reduce production costs.

In 2012 industry leader, Xylem, announced their new modular control and monitoring device, the Flygt APP 800 (Figure 9.14), was to include a colour touch screen for improved user friendliness and clear display of energy consumption (Xylem Inc., 2012). This indicates that Xylem believes customers are demanding greater product flexibility, enhanced user friendliness, and energy focused solutions. If these views are correct then Sulzer will need to adapt its product to compete.

Figure 9.14. The Xylem Flygt APP 800 control and monitoring system

9.13.4 Creating a Innovation Culture

Several innovation experts suggest that large corporate companies are very unlikely to successfully foster innovation (Ashkenas, 2013; Hisrich, Peters, & Shepherd, 2005). This view is generally based on a belief that the traditional corporate culture does not create a receptive environment for innovative and entrepreneurial work. Some typical traits on the traditional corporate culture are:

1. Conservative low risk decision making
2. Low flexibility in execution of instructions
3. Lack of personal responsibility amongst staff
4. Low tolerances for creativity in work
5. High expectations for return on investments
6. High levels of bureaucracy

These traits generally oppose innovative and entrepreneurial work styles that are best suited to customer focused innovation projects. Managing resources to avoid these points may increase the prosperity of the ABS control and monitoring business model.

To encourage an innovative culture around business innovation projects it is suggested that organisation changes be made to 1) facilitate fast communication and authorisation times (Figure 9.15), and 2) permit business innovation staff the freedom to experiment with new practices, i.e. sales strategies, marketing strategies, management strategies, etc. The first point will give Sulzer the agility of a small company for quickly refining business models to suit changes in market condition or customers needs. This ability to rapidly adapt business models to meet changes in the market is considered critical for successful business model innovation (Wallin, Chirumalla, & Thompson, 2013). The second point will allow novel business models to be explored and validated which is important for Sulzer to differentiate itself from its competition.

Allowing business innovation programs to experiment with new strategies will be particularly difficult for Sulzer since its centralised structure imposes many standards across the company. This has already limited development of the ABS business model as Jörgen

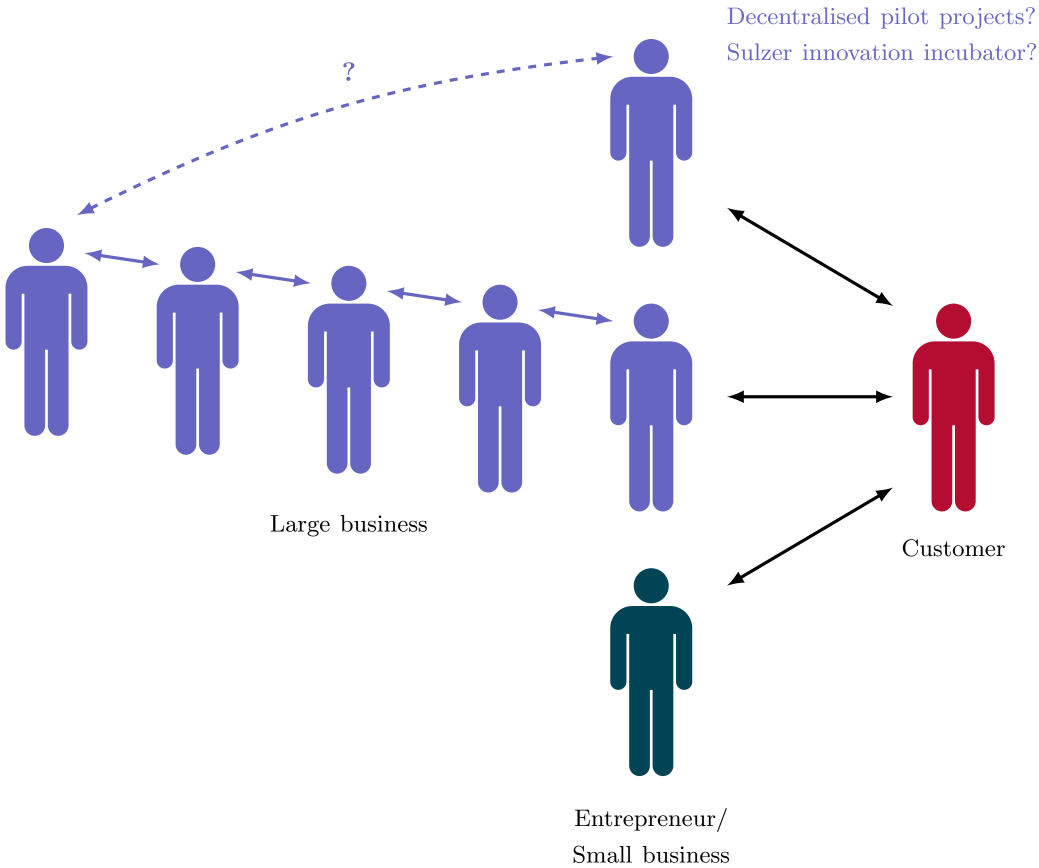


Figure 9.15. Minimising extensive management levels may improve the time taken to refine business models according to customer feedback by reducing communication and authorisation times

Jäger (ABS control and monitoring product manager) states that he has been restricted from exploring new marketing concepts outside of the Sulzer marketing team standards. To promote exploration of new ideas it is suggested that pilot business innovation projects be formed that are permitted to work outside of the normal Sulzer standards (Figure 9.15).

9.14 Summary

In this chapter, the current ABS control and monitoring business model was investigated and analysed to firstly document its design, and secondly to identify areas of improvement. Market feedback validated that the current value proposition is very competitive. However, channels for value awareness and evaluation are weak and are leading to poor product sales. Moreover, channels to connect with customers and maintain customer relationship are limited to customer contact through Sulzer sales and CSS staff.

Overall the Sulzer ABS business model has a low degree of novelty and no lock-in features, while complementarily effects with pump equipment business are weak. The efficiency of the business model was not quantified. However, given the dispersed locations of key activities it is assumed that efficiency gains could be made by improving communications and reducing logistic needs.

To improve the business model it was suggested that sales staff training activities and digital marketing material be updated. More specifically, sales staff training needs to be offered to more sales staff around the globe and ensure that these staff members have a good knowledge of ABS control and monitoring solutions. Improvements in marketing material should include features to convey ABS control and monitoring devices and Sulzer pumps as complementary products, and more means for customers to easily access Sulzer product data.

Currently ABS control and monitoring business creates and captures value independently as well as via complementary effects with Sulzer pump equipment business. However, since these complementary effects are not easily quantified it is believed that control and monitoring business within Sulzer is undervalued. For example, it is believed that approximately 50 % of control and monitoring revenue is hidden within pump equipment sales figures and do not contribute towards control and monitoring profitability. Furthermore, it is difficult to quantify intangible value captured by ABS control and monitoring business, such as data which gives insight into customer needs and the 'real world' performance of Sulzer pump products, and market knowledge gained by Sulzer staff during the customer development process. Failure to recognise and invest further in these complementary effects for intangible returns may diminish opportunities for Sulzer to penetrate the control and monitoring market for tangible returns in the future.

Chapter 10

Conclusion

10.1 Summary of Results

Results of the current study are summarised in the following subsections. Firstly, Section 10.1.1 and Section 10.1.2 summarise customer demand for machine monitoring solutions in general, and the current market conditions in each of Sulzer's focus industries respectively. The combination of these results provides an overview of the future market requirements for machine monitoring in Sulzer's key industries. Secondly, Section 10.1.3 and Section 10.1.4 review the current development work on machine monitoring business models in oil pipeline and wastewater industries, and include recommendations for further penetrating these markets.

10.1.1 Customer Demand

This study investigated the market demand for machine monitoring in the industries of oil and gas, hydrocarbon processing, power generation, water, pulp and paper, and general industry in order to specify a suitable customer segment and value proposition for machine monitoring business. In addition to a review of publicly available statistics, regulations, and news and for each industry, Sulzer sales and customer support services (CSS) staff were surveyed to estimate customer demand. Survey results indicated that customer needs and levels of demand vary significantly with industry and region, and also that Sulzer Pumps currently has a low level of engagement with customers in the machine monitoring market. For instance, only 20 % of Sulzer Pumps sales and CSS staff currently discuss machine monitoring solutions with customers on a weekly basis.

Sales and CSS staff survey responses resulted in 'avoiding equipment downtime' being the primary goal of most customers for reducing their life cycle costs. Secondary and tertiary goals were avoiding major equipment failures, avoiding unplanned maintenance, saving energy costs, or process optimisation depending on industry. Overall the industries of oil and gas, hydrocarbon processing industry, pulp and paper, and general industry tended towards reliability focuses goals while the industries of power generation and water tended to be focused on efficiency goals.

Sales and CSS staff believed that automated monitoring systems were most interesting for customers due to their potential for saving on labour costs. However, the cost of automated monitoring systems often deterred customers from using them and led them to them using less expensive walk-around monitoring solutions. In particular, new equipment customers that were not end users, i.e. engineering and procurement companies, are particularly difficult to sell monitoring solutions to since they are not concerned with the equipment operating cost.

Overall, the broad application range of machine monitoring equipment means that machine monitoring is demanded by customers for many purposes in all of Sulzer's focus market markets. Sulzer Sales Manager Sam Dugan reports that "customers do see value in the product, and in fact I would say that it is now an expectation from customer that as a manufacturer we supply control and monitoring for our pumps. Similarly Flavio Sacramento, a Sulzer Pumps tendering manager stated that "in the market of engineered equipment it (machine monitoring) is a mandatory expectation. Given this market feedback it is recommended that Sulzer Pumps work towards having standard machine monitoring offers in the future.

10.1.2 Favourable Markets

As part of the current study, the business model environment of each Sulzer focus market was investigated to determine the most favourable market for new machine monitoring business. As part of this investigation each business segment head completed a survey aimed at establishing the attractiveness of each market and Sulzer's competitive position. The results of this survey yielded that the power generation, water, and process pump markets were most favourable for future machine monitoring ventures and should be investigated further. Following this outcome a decision was made to investigate the power generation, water, and pipeline industries for monitoring opportunities in more detail.

A review of the power generation industry revealed that conventional fossil fuel electricity generation continues to dominate existing infrastructure capacity. However, regulations are driving up the capacity share of the renewable energy plants. Renewable energy power plants are now considered to provide the grid base load which has forced conventional power plants providing top up loads to start and stop more frequently. This increase in start-stop frequency has increased wear on machinery and called for machine monitoring to sustain reliability.

Opportunities exist in monitoring engineered pumps in the electricity generation market. However, such large pumps are usually already monitored by plant central control systems. Hence additional are not considered in high demand. Furthermore, a recent Eurelectric survey (Eurelectric, 2011) of thermal power plants revealed that generators and thermal systems cause more problems than pumps, and hence they are more likely targets for monitoring investments. Generator monitoring opportunities may be worth investigating further. However, generator monitoring business would be more aligned with the activities of Sulzer Turbo Services.

Unlike the electricity generation value chain, the district heating value chain relies heavily on pumps. Hence there is greater potential for pump monitoring business in the district heating industry. Thus said, monitoring opportunities in the district heating industry are limited to countries which have district heating or district cooling infrastructure. The main control and monitoring demands in the district heating industry are driven by the need for leak detection and network pressure control.

The clean water distribution industry has similar interests to the district heating, i.e. smart pressure control for energy cost savings and leak detection for product loss savings. Clean water production utilities also demand means for energy cost savings, particularly at desalination plants where energy costs form the majority of the total plant operational costs. The wastewater segment has similar demands to clean water, i.e. they are interested in energy cost savings, with additional demands such a blockage control and cleaning cost savings.

Monitoring opportunities in the water industry are considered attractive for Sulzer Pumps since Sulzer already has established business in both the water supply and sanitation segments, and already has control and monitoring solutions for the wastewater industry. Moreover, the water industry is a large and relatively stable market since people will always require water to live. Thus said, customer demands are not uniform around the world and vary significantly with region.

10.1.3 Opportunity in the Oil Pipeline Industry

The majority of the oil and gas pipelines are located in the United States of America. Russia, Canada and China also have large lengths of pipeline. However, their pipelines combined still do not equate to those in the U.S. The majority of U.S. pipelines transport gas while the minority contain liquids such as crude oil, liquefied petroleum gas, and other refined products. These pipelines span hundreds of kilometres across the U.S. and require monitoring for reliable operation. Firstly, the pipe itself requires monitoring to maximise safety and minimise potential environmental damage. Secondly, equipment on the pipeline must be monitored to maintain smooth operations.

Drivers supporting pipeline monitoring in the U.S. include environmental and safety regulations, pressure from environmental organisations, pressure from the general public, and cost saving goals of pipeline operators. Unfortunately the majority of these drivers support pipe monitoring opportunities rather than pipeline equipment monitoring opportunities. Nevertheless, pipeline operators still demand pipeline equipment monitoring to minimise their maintenance and energy costs.

To evaluate Sulzer Pumps capacity for providing pipeline monitoring solutions, Sulzer Pumps current capabilities were compared to the requirement of a recent request for proposal from ConocoPhillips Pipeline, a pipeline operator in the U.S. (now named Phillips 66 Pipeline Company). This analysis concluded that Sulzer does not currently have the resources or experience to offer a competitive machine monitoring solution in the oil pipeline industry. Moreover, if Sulzer was to pursue machine monitoring business in the oil pipeline industry, the business model would rely heavily on key partners with oil pipeline monitoring experience.

Sulzer Alliance Mangers were asked to indicate whether they saw opportunities for Sulzer Pumps in the oil pipeline industry. However, unfortunately the majority of alliance managers responded unfavourably. The main reasons for oil pipeline customer lacking interest in machine monitoring business with Sulzer is that they already have established machine monitoring activities on their own or with a competitor of Sulzer.

Sulzer Pumps is currently providing machine monitoring services to Chevron Pipeline Company. However, these services are outsourced to the contractor Pro Pump Services. If Sulzer Pumps is to pursue machine monitoring business in the oil pipeline industry it is recommend that Pro Pump Services be considered as a key partner or an acquisition target to better Sulzer's competitive position.

10.1.4 Current Sulzer Control and Monitoring Business

Sulzer Pumps machine monitoring offers are currently limited to ABS control and monitoring solutions for the wastewater industry. In the current study, the business model behind these offerings was analysed to identify areas in which it could be improved. This investigation concluded that the current value proposition is very competitive, but the channels through which Sulzer interacts with its customers could be greatly improved. Suggestions to improve the current ABS control and monitoring business model included improving digital communication and marketing, increasing the frequency of sales and CSS staff product training, and improving connections between pump and monitoring products in marketing material. All of these suggestions aim at improving customer value awareness.

10.1.5 Organisational Issues

Sulzer exhibits the typical characteristics of a large company that are, conservative low risk decision making, low flexibility in execution of instructions, low tolerance for creativity in work, high levels of bureaucracy, and high expectations for return on investment.

Although Sulzer may have these characteristics for good reason it is important to recognise that they do not create a receptive environment for innovative work. To improve this situation it is recommended that Sulzer consider changes in organisation and internal funding structure that would cater for high risk pilot projects, such as new control and monitoring business ventures. For example, under a less restricted environment with fewer consequences of failure, business development staff will be more likely to experiment with novel business models and hence have a greater opportunity discovering successful innovative business models. However, opportunity for failure will still remain and hence monitoring the successes and failures of business model development programs will be very important to ensure structured and efficient business model developments.

10.2 Recommended Future Research

The follow sections contain suggestions for future work that have been separated into three development areas. Firstly, future business model development work including market research to improve Sulzer's commercial success (Section 10.2.1). Secondly, technical research and development tasks to ensure Sulzer products maintain a competitive advantage (Section 10.2.2). Thirdly, organisational tasks to assist Sulzer in adopting machine monitoring business (Section 10.2.3).

10.2.1 Business Model and Market Research

In the current study, machine monitoring business models for the oil pipeline and wastewater markets were investigated. However, only the wastewater market was recommended as a favourable environment for Sulzer machine monitoring business. After the current ABS control and monitoring business model was evaluated, suggestions were made to improve its performance. It is recommended that future work continues to track and record the progress of ABS control and monitoring business so that experience gained during this primary machine monitoring venture is not lost.

The most important recommendation for improving the current ABS business model was that a sales and customer support service (CSS) staff training program should be designed and implemented. The impact of this action on the business model is two fold. Firstly, better staff training will increase sales and CSS staff knowledge of Sulzer ABS control and monitoring products, and allow them to confidently discuss product features and benefits with customers. This should increase Sulzer control and monitoring product sales. Secondly, improved staff training will allow sales and CSS staff to independently handle most technical issues customers have with Sulzer ABS control and monitoring products. This will decrease the dependence of sales staff, CSS staff, and customers on research and development staff for technical assistant, and hence allow research and development staff to focus on product developments.

Other future research should evaluate markets where the current Sulzer ABS technology or similar technology could be transferred to. For example, it is recommended that the competitiveness of ABS control and monitoring solutions is evaluated for applications in the clean water market. Currently a 'black box' monitoring device has been prototyped at Sulzer. Future research should also include evaluating markets for this device and implementing a customer development program. The current study identified that some industries, such as the power generation industry, demand the services of both Sulzer Pumps and Sulzer Turbo services. Opportunities for collaborative developments between these two divisions should be clearly identified by future research, and subsequently concept business models based around these developments should be designed and validated.

10.2.2 Technical Research

As mentioned in Section Section 10.2.1, Sulzer has recently prototyped a blackbox monitoring device for applications in the power generation industry. It is recommended that the technical development of this blackbox monitoring device be continued in close collaboration with customer development programs. This is important for two reasons. Firstly, it is essential that the product is initially developed to satisfy the target customer needs, and secondly, the product may require further technical development if a new customer segment is discovered and validated.

It is also highly recommended that development of the next generation of Sulzer machine monitoring devices commence soon so that Sulzer technology stays ahead of competitor offerings. In particular, it is recommended that the second generation IntO machine monitoring device (see Section 3.6.6) be developed as its modular design would provide Sulzer Pumps with the flexibility to enter machine monitoring markets in several industries. Technology from the existing Sulzer ABS control and monitoring solutions, the first generation IntO, and the Sulzer ABS HST turbocompressor should be used to support this development.

As mentioned in Section 9.9.3, the majority of the current ABS control and monitoring research and development budget actually finances day-to-day control and monitoring business operations. In the future it is important ensure that technical research and development has adequate funding separate from operational budgets used for product maintenance, otherwise Sulzer technology risks losing its competitive advantage.

10.2.3 Business Development and Managerial Tasks

In March 2013, Sulzer's Head of Machinery Dynamics and Acoustics, Frank May, attended the Global Remote Service in the Machinery Industry Conference with representatives from other major industrial equipment manufactures. As a result of discussions at this conference, Frank concluded that "if condition monitoring was successful (within a company), in most cases it was by massive impact and commitment of the CEO". This is an important observation that Sulzer must learn from. Hence, presenting C-level management with a solid business plan for machine monitoring business is an important task which needs to be completed in the near future.

At present it is still unclear whether Sulzer will continue to invest in machine monitoring since no clear business plans currently exist. Moreover, Sulzer Pumps Business Development Manager, Miriam Thomas, has indicated that it is unlikely that Sulzer will further invest in machine monitoring business without a business plan that outlines clearly how profits will be generated. In this business plan financial profits must be estimated. However, intangible value gained through machine monitoring business is of no interest to business development staff.

Although complementary business and intangible value generated through machine monitoring business (e.g. monitoring data, customer loyalty, complementary pump sales, complementary service work, etc) is not immediately interesting to business development staff, these business outputs may support financial returns. Recognising and estimating revenues generated through complementary effects will be an important task to ensure that the value of future machine monitoring is fully and fairly evaluated. Hence it is recommended that future work be done on creating a method for such an evaluation to clearly illustrate the tangible and intangible returns of machine monitoring business.

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Appendix A

Sulzer Employees Mentioned in this Report

Name	Job Title	Location
Bruce Susilovich	Alliance Manger for Phillips 66	Sulzer Pumps, Shreveport, Louisiana, U.S.A
Christopher Schempf	Alliance Manager for Marathon Pipeline	Sulzer Pumps, Joliet, Illinois, U.S.A.
Daniel Snchez Tadeo	Sales Manager	Sulzer Pumps, Madrid, Spain
David Drewe	Alliance Manager for Shell and BP	Sulzer Pumps, Milton Keynes, U.K.
Dennis Bruce	Field Support & Maintenance Manager	Sulzer Pumps, Thornton, Colorado, U.S.A.
Frank Ennenbach	Director of Product Safety and Regulations	Sulzer Pumps, Lohmar, Germany
Frank May	Head of Machinery Dynamics and Acoustics	Sulzer Innotec, Winterthur, Switzerland
Joachim Schulz	Head of Power generation Business Segment	Sulzer Pumps, Winterthur, Switzerland
Jörgen Jäger	ABS C&M Product Manager	Sulzer Pumps, Stockholm, Sweden
Kevin Sparks	Sales Manager	Sulzer Pumps, Brisbane, Australia
Marc Redit	Head of Wastewater Business Development	Sulzer Pumps, Winterthur, Switzerland
Marcos Koyama	Head of Water Business Segment	Sulzer Pumps, Winterthur, Switzerland
Niko Toikka	Service Manager	Sulzer Pumps, Kotka, Finland
Pat Hudgens	Alliance Manger for Enbridge	Sulzer Pumps, Novi, Michigan, U.S.A.
Paul Christnacht	Alliance Manger for Phillips 66 and ExxonMobil	Sulzer Pumps, Brookshire, Texas
Pekka Salmi	Head of CSS for Sulzer Process Pumps	Sulzer Pumps, Kotka, Finland
Per Askenström	C&M Research and Development Manager	Sulzer Pumps, Stockholm, Sweden
Rich Niinanen	Head of Oil and Gas Business Segment	Sulzer Pumps, Portland, Oregon, U.S.A.
Rick Hannegan	Alliance Manger for Chevron	Sulzer Pumps, Brookshire, Texas, U.S.A.
Robert Santiso Vazquez	Sales Manager	Sulzer Pumps, Meriden, Connecticut, U.S.A.
Sabine Sulzer	Innovation Manager (Jan 2007 – May 2012)	*No longer at Sulzer*
Sam Dugan	Sales Manager	Sulzer Pumps, Brisbane, Australia
Shelagh Tucker	Electrical Engineer	Sulzer Turbo Service, Winterthur, Switzerland
Steve Friendship	UK Sales Manager	Sulzer Pumps, West Sussex, U.K.
Thomas Sendelbach	Head Global Sales Tools	Sulzer Pumps, Winterthur, Switzerland
Ton Vrenegoor	Industrial Accountant	Sulzer Pumps Solutions, Wexford, Ireland
Ueli Buxtorf	Tribology and Lubrication Specialist	Sulzer Metco, Winterthur, Switzerland

Appendix B

Machine Monitoring Customer Demand Evaluation Survey

Participant Information

1. Participant name:

2. Job title:

3. Select the industry segments that you work in:
   (a) Oil and gas
   (b) Hydrocarbon processing
   (c) Power generation
   (d) Water
   (e) Pulp and paper / General industry

4. Select the business segments that you work in:
   (a) EMEA
   (b) AME
   (c) ASP
   (d) Configured Solutions

5. Your experience at Sulzer:

Machine Monitoring Survey Questions

6. Do you believe that asset life cycle cost minimisation is important to our customers? If yes, for what reasons? Please list any customers that come to mind.

7. To your knowledge do our customers use life cycle cost modelling to aid in life cycle cost minimisation? If so, please estimate the proportion of customers that use life cycle cost modelling.

8. Please rate how important the following are to the majority of our customers and state a reason why.

	Not Important	Interesting but not important	Moderately important	Very important	Essential	Reason
Minimising energy costs						
Minimising maintenance labour costs						
Maximising pump working life cycle duration						
Protecting equipment from major failure						
Minimising downtime or loss of production						
Minimising spare parts or consumables used						
Operating pumps at their best efficiency point						
Maintaining good pumping efficiency						
Avoiding unplanned maintenance						
Proper planning of maintenance						
Other? Please specify:						

9. On the scale below, where do you think the majority of our pump customers are in terms of machine monitoring interests? (Select N/A if you think our customer do not care about either)
   - 1 Totally focused on asset reliability
   - 2
   - 3
   - 4
   - 5 Totally focuses on energy cost minimisation
   - N/A

10. What proportion of customers would you estimate already use monitoring equipment or services?

11. What monitoring methods are popular with our customers? Please explain each choice.

	Popular	Not popular	Reason
Automated machine protection			
Walk around monitoring			
Black box event monitoring			
Continuous online monitoring			
Optimised operation			
Automated diagnostics			
Predictive maintenance program			
Automated energy management			
Other? Please specify:			

12. Which monitoring equipment or service providers are currently most popular with our customers? Do you know why?

13. In your opinion, do you think our customers are satisfied with their current condition monitoring data analysis and interpretation solutions? Please explain your answer.

14. Do our customers that currently use monitoring equipment or services measure their return on these investments? If so, how?

15. What condition monitoring technologies do our customers show the most interest in and why?

16. How often do you discuss machine monitoring with our customers? (e.g. once a month, twice a week, never)

17. If you could provide any service to Sulzer Pump customers, what do you believe they would most benefit from?

Appendix C

Market Segment Evaluation Survey

	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
Market attractiveness questions				
How broad are the machine monitoring needs of customers in your business segment?				
How strong are machine monitoring competitors in your business segment? Please comment on their strengths and weaknesses.				
How strongly do future legislations and regulations promote machine monitoring business in your business segment?				
How strong is customer demand for machine monitoring in your business segment?				
How strongly is the machine monitoring market controlled by standardisation in your business segment?				
How mature is currently available machine monitoring technology in your business segment?				

	Low/ Weak	Moderate	High/ Strong	Reason/ Comments
Sulzer's competitive position questions				
How strongly would Sulzer Pumps have to invest to enter the machine monitoring market in your business segment? (Please consider the breath of the current product line, patented technology, current product developments, etc)				
How developed is Sulzer Pump's experience and knowledge in machine monitoring within your business segment? Please comment on experience in product/service development, technology, sales, etc.				
How transferable would machine monitoring technology, developed for your business segment, be to other business segments? Please comment on your choice.				
How strong is customer loyalty to Sulzer Pumps in your business segment?				
How high is Sulzer Pumps market share relative to our competitors in your business segment?				
How frequently do customers show interest in machine monitoring in your business segment?				
How keen is Sulzer Pumps to offer machine monitoring solutions in your business segment?				

Appendix D

ABS Pump Controller Comparison with Competitor Products

Manufacturer	Sulzer ABS			Xylem			Grundfos	KSB
Pump controller model	PC 111/ PC 112	PC 242/ PC 441	PCx	APP 500	APP 700	Logimac	CU 362	DDPi/ DSPi
Price	€310/ €320	€475/ €865	€ 880					
General								
Number of pumps	1 - 2	2 - 4	$\leq$16	1 - 4	1 - 4	1 - 4	$\leq$6	1 - 2
Embedded control/PLC	Embedded	Embedded	Embedded	Embedded	Embedded	PLC	Embedded	Embedded
VFD compatible	✓	✓	-	-	✓	280 VMT	✓	-
Measurements & Calculations								
Level sensing - float type	✓	✓	✓	✓	-	210/220	✓	✓
Level sensing - level sensor	✓	✓	✓	✓	✓	280 VMT/480	✓	-
Tank inflow	-	✓	✓	-	✓	-	-	-
Tank outflow (pumped volume)	-	✓	✓	✓	✓	-	✓	-
Pump vibration	-	-	-	-	-	-	-	-
Pump motor current	✓	Ext. device	Ext. device	✓	✓	280 VMT/480	✓	✓
Pump/motor temperature	✓	✓	✓	✓	✓	✓	✓	✓
Moisture/Leakage detection	✓	✓	✓	✓	✓	✓	-	-
pH monitoring	-	-	-	-	✓	-	-	-
Rain meter	-	✓	-	✓	✓	-	-	-
I/O expansion modules	-	✓	✓	-	✓	-	✓	-
Energy calculations	-	Ext. device	Ext. device	-	✓	-	✓	-
Data logging								
Alarm logging	w/o time rec.	✓	✓	✓	✓	✓	✓	-
Sensor data logging	-	✓	✓	✓	✓	-	✓	-

Manufacturer	Sulzer ABS			Xylem			Grundfos	KSB
Pump controller model	PC 111/ PC 112	PC 242/ PC 441	PCx	APP 500	APP 700	Logimac	CU 362	DDPi/ DSPi
Intelligent functions								
Float failure detection	-	-	-	-	✓	210/220	-	-
Pump failure detection	✓	✓	✓	✓	✓	✓	✓	✓
Advanced alarm handling	-	✓	✓	-	-	-	✓	-
Automatic blockage handling	PC 111	✓	✓	-	-	-	✓	-
Random water levels	-	✓	-	-	-	-	✓	-
Pump alternation	-	✓	-	-	✓	✓	-	-
Connectivity								
Annunciator panel	✓	PC 242	Ext. device	✓	✓	✓	✓	✓
Operator interface	✓	PC 242	Ext. device	✓	✓	280 VMT/480	✓	✓
USB port	-	PC 441	-	-	-	-	✓	-
RJ45 Ethernet port	-	-	-	✓	✓	-	✓	-
RS232/RS485 port	-	RS232	✓	-	✓	✓	RS485	-
Mobile app	-	✓	Ltd. Func.	-	-	-	✓	-
Remote control	-	✓	-	✓	✓	-	✓	-
Remote servicing/upload	-	✓	✓	-	✓	-	-	-
Web Server	-	✓	-	-	✓	-	Ext. device	-
SCADA ready	-	PC 441	✓	✓	✓	✓	✓	-
GPRS/GSM modem	-	Ext. device	Ext. device	Optional	✓	-	Ext. device	-
Configuration software tool	✓	✓	✓	-	-	-	✓	✓
Security								
Password protected	-	✓	-	✓	✓	280 VMT/480	✓	-
Intrusion alarms	-	-	-	-	✓	-	-	-